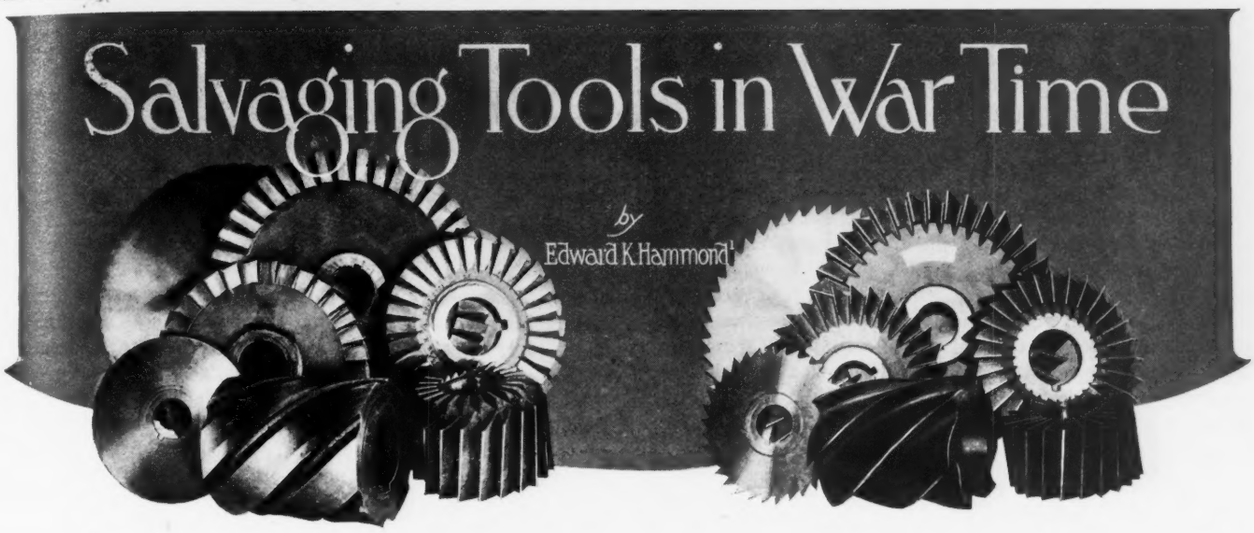
Salvaging Tools in War Time

by Edward K. Hammond[1]



Metal-cutting tools which have been worn or damaged in a way that makes them unfit for service can be economically reclaimed by firms making a specialty of tool salvaging operations. Current prices of tools are far above the catalogue list prices, and this condition has led many manufacturers who formerly discarded worn-out tools to adopt the practice of having them salvaged. The savings made possible by this method are so manifest, however, that it seems certain that many who adopted this as a war-time measure will continue the practice when industry once more returns to normal conditions. This article explains the charges made for salvaging tools, the savings made possible by this practice as compared with selling worn-out tools at their junk value and buying new ones, and gives a brief outline of the method of procedure in salvaging several commonly used types of metal-cutting tools.

IN operating a manufacturing plant in a country that is rich in natural resources, the practice of thrift in the use of raw material is likely to be regarded as unnecessary; but as the resources of that country become less plentiful, and prices rise as a consequence, thrift very naturally becomes a matter of necessity. The rise in prices of materials, which naturally follows the depletion of supplies as a country grows older, is brought about artificially in war time, due to an increased demand for materials, to the reduction in purchasing power of money, and to various other causes. As a result, the practice of thrift in the management of an industrial plant in war time becomes even more necessary than in times of peace, owing to the absolute dependence of every army upon the product of the manufacturing plants in the country for which it is fighting.

American manufacturers have made one noteworthy change in their methods of management during the last two decades. When raw materials were more plentiful and cheaper than they are today, the improvement of rates of production was the factor that was constantly demanding attention. Now, the maintenance of production rates is still of the utmost importance, but reduction of production costs through the conservation of materials has been assuming a steadily increasing importance, until today it ranks with keeping up the rate at which product is turned out. Numerous examples could be cited of the way in which this change has affected manufacturing practice in general, and machine shop practice in particular. In this article it is the intention to describe the salvaging of various types of cutting tools that are used in the machine shop, and to explain the saving that is effected through salvaging these tools as compared with selling the worn-out tools for junk and replacing them with new ones. Economic conditions existing shortly before the war had demonstrated the need of eliminating serious losses which resulted from the quite general practice of discarding worn-out cutting tools; but with the outbreak of war, and the great increase of the price of tool steel, due to reasons that have already been mentioned, tool salvage became one of the important factors in meeting the greatly increased demand for milling cutters, reamers, etc., to satisfy the requirements of industry during war time.

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Established Practice in Salvaging Tools

In some shops, a tool is regarded as worn out when the teeth have been ground down to a point where it is under size or where there is insufficient space for the escape of chips. When a tool has reached this condition, there is generally a lot of good steel which could be utilized by salvaging the tool to adapt it for further service. Two methods of procedure are possible in salvaging tools, *i.e.*, the steel may be annealed and the tool recut and rehardened, or a grinding wheel may be used to regrind the teeth to the required depth without the necessity of any heat-treatment. It is almost universal practice to employ the latter method, because trouble is likely to be experienced in attempting to reheat-treat a tool—particularly in the case of high-speed steel. Most manufacturing plants find it more economical to send out their old tools to be salvaged by concerns making a specialty of this work than to attempt to salvage them in their own shops. When one begins to consider the various factors which enter into handling the work of tool salvaging, it at once becomes apparent that the requirements of this work are somewhat peculiar. In the first place, cutting tools are sent out from a manufacturing plant to be salvaged after they have been worn under size or become scored, bent, or otherwise made unfit for service. There are three possibilities in handling the work in so far as the size of the reclaimed tools are concerned: (1) This size could be the same as the original size of the worn tools which are to be reclaimed. (2) The tools could be ground down to the largest size possible without employing special treatment to expand them back to the original size. (3) The tools could be ground down to the next standard size by intervals of 1/8 inch on the diameter and by 1/16 inch on the width of face.

In practice, there are two methods which are almost universally followed with the exception of methods used in reclaiming reamers. In handling all kinds of cutters, it is almost the universal practice to reduce them to the next standard size by intervals of ⅛ inch on the diameter and by intervals of 1/16 inch on the face width, because most manufacturers have their tool cribs arranged with cutters classified according to size, and with such an arrangement there would be confusion if the salvaged tools were of bastard sizes. In reclaiming reamers, this practice of reducing to the next standard size is also followed, but to meet the requirements of manufacturers who have certain standard reaming operations

to perform, and who therefore require their reamers to be reclaimed back to these standard diameters, the Peninsular Tool Salvage Co., Detroit, Mich., have developed a method of swaging the reamer blades to increase the diameter of the tool so that it can be ground back to the original standard size. On the other hand, there are many firms who are using a variety of sizes of reamers, and such firms can use their reamers satisfactorily when they are salvaged by grinding down to the next standard diameter by intervals of ⅛ inch.

As an example of practice in reducing milling cutters to the next standard size, the following instance will explain just how the proposition works out. Take the case of a milling cutter 6 inches in diameter by ¾ inch width of face. This cutter will be about 5 9/16 inches in diameter by 11/16 inch wide when received by the tool salvage concern. The diameter will be reduced 1/16 inch to 5½ inches, which is the nearest standard diameter, while the width of face will be left 11/16 inch; in other words, no reduction is necessary on either the diameter or the width of face, unless it is necessary to reduce the size of the cutter to the next standard ⅛-inch interval on the diameter, or the next standard 1/16-inch interval in width. The work is done within commercial limits. Mills for cutting splined grooves in shafts are regularly salvaged and held to the original width. Where special instructions are given to leave both the diameter and width of face as large as possible, tools can be salvaged to within 0.005 inch of each of the dimensions of the tools as they were received at the salvaging shop. The diameter of reamers is usually reduced to the next standard size by intervals of 1/16 inch, although the practice of reducing to the next standard size by ⅛ inch may be followed or the diameter may simply be reduced 0.005 inch.

Care Taken to Avoid Burning Steel while Salvaging Tools

When firms making a specialty of salvaging tools first started to solicit business, they were told that it would be impossible to grind tools down to form new teeth, because the heat generated during the processes of grinding would burn the steel and make the tools unfit for further efficient service. This criticism calls attention to a point that is of great importance in salvaging tools, as it is certainly most necessary to take great care in conducting the grinding operation to avoid burning the steel, if tools are to be successfully salvaged. Various precautions are observed by the different firms engaged in this work, but generally speaking, these include the use of a soft free-cutting wheel that will break down rapidly enough both to maintain sharp cutting edges on the abradant and to prevent creating a glazed condition of the wheel that is likely to result in burning the work. So far as the use of a coolant is concerned, there is considerable diversity of opinion. Many operations are performed dry with satisfactory results, provided the right kind of grinding wheel is used; but for certain classes of work, some tool salvaging firms maintain that better results are secured through the use of a liberal volume of coolant on the grinding wheel and work, while others claim that the use of coolant on high-speed steel results in producing small cracks that will cause the tool to fail soon after it has been placed in service.

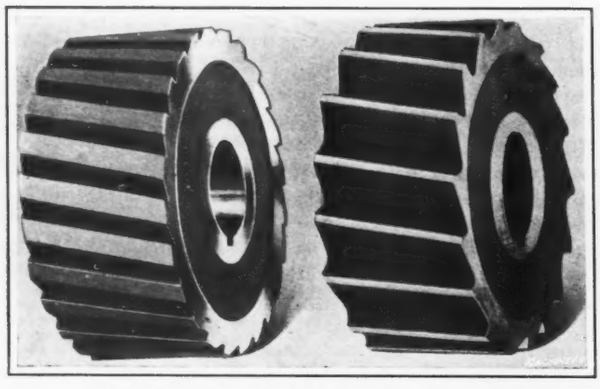


Fig. 1. Plain Milling Cutter before and after it was recut by Peninsular Tool Salvage Co.

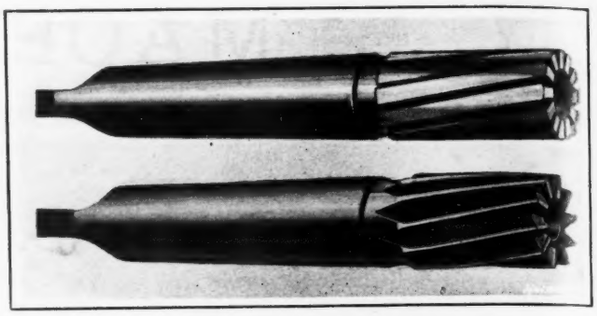


Fig. 2. Taper Shank End Milling Cutter before and after it was recut by Peninsular Tool Salvage Co.

Consideration of Salvaging Requirements when Designing Tools

Some tools of a given type lend themselves much better to the requirements of salvaging than other tools, because the tooth form, arrangement of clearances, etc., are so arranged that salvaging is quite easily accomplished. In other tools, which are capable of giving equally satisfactory results when new, the design may be such that the salvaging possibilities of the tool are quite limited. The Goddard & Goddard Co., Detroit, Mich., do a business both in the salvaging of old tools and the manufacture of new ones. The new tools are especially designed with a view to their subsequent salvaging, and with these tools far more service can be obtained than is possible with many other types of cutters. The trade name "Go and Go" has been adopted by this company to designate its tools, because it is claimed that salvaging may be continuously repeated so that the tool diminishes in size until practically all of the steel is "gone." For instance, it is possible to start with one of the "Go and Go" side milling cutters and reduce this cutter several times to smaller sized cutters of the same type; then it can be converted to a slitting saw which is capable of being salvaged several times more.

Cost of Salvaging Tools

Purchasing agents of manufacturing plants have become so accustomed to receiving quotations which are list prices and subject to certain discounts that firms engaged in the tool salvage business have adopted a similar method of quoting prices for the service which they render. These concerns conduct their business along the following lines: The manufacturing plant which desires to have its tools salvaged sends them to the shop making a specialty of this work, and they are listed in the receiving room according to the original sizes which are stamped on the tools. The salvaging process is then carried through to completion and the tools are shipped back to the customer. The financial end of the transaction is carried through just as if the salvage firm were selling new tools to the customer, the price charged being the list price of new tools of the original size, less a discount, which is usually 60 per cent. In other words, the salvaging concern generally charges 40 per cent of the cost of new tools of the original size for the work of putting them back into condition for rendering subsequent service; but it is important to note that this is based on the old list price and not on the much higher prices at which all high-speed cutting tools are now selling.

Before the tools are returned to the customer, the old marking has been removed and they are marked with the size to which they have been reduced by salvaging—except in the case of chucking reamers which may be swaged out so that they may be reclaimed to the original size—and when these tools come back to the shop for the next salvaging process, the charge for the work is, of course, based upon the size to which they were reduced during the previous treatment. The same method of charging for work is followed in the case of both high-speed and carbon steel tools, so that the remuneration received for salvaging carbon steel tools is necessarily much less than in the case of high-speed steel tools; in fact, the average price received for salvaging carbon steel tools represents just about the cost of doing the work, no profit being made in many cases.

Money Saved through Salvaging Worn-out Tools

When consideration is given to the relative merits of selling worn-out tools as junk and buying new tools, or of having the worn-out tools salvaged, the question will quite naturally be asked, "How much can be saved by going to the trouble of packing up old tools and shipping them to a salvage shop?" In order to answer this question we have obtained information from tool salvage firms which shows the actual saving in specific instances. The table presented in connection with this article gives complete data concerning the salvaging of different types of tools that are handled by the Peninsular Tool Salvage Co. of Detroit, Mich. It will be seen that two or more examples are given for each type of tool, and it will be evident from the preceding discussion that the cost of salvaging is 40 per cent of the list price of the tool when new, while the saving by salvaging the tool is obtained by subtracting the cost of salvaging from the list price of a tool of the size obtained by salvaging the worn-out tool. Owing to the exceptional demand which now exists for all types of cutting tools, current market prices are greatly in excess of the list prices given in manufacturers' catalogues. Consequently, a column is included in the table giving the present market prices of high-speed steel cutters of the recut size, and the saving effected by salvaging the tools has been calculated both for the list price of each tool of the recut size and for the present market price of this tool. An exception is noted in the case of chucking reamers, where the cost of bringing the tools back to the original diameter is 50 per cent of the list price when new, instead of 40 per cent as in the case of other tools.

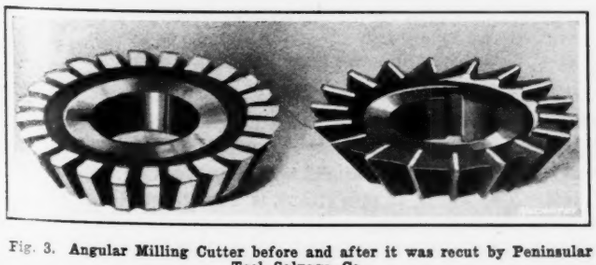


Fig. 3. Angular Milling Cutter before and after it was recut by Peninsular Tool Salvage Co.

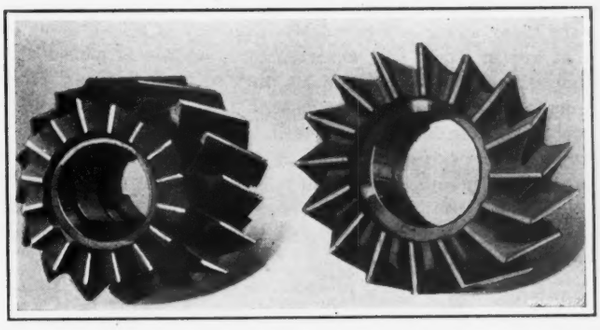


Fig. 4. Shell End Milling Cutter before and after it was recut by Peninsular Tool Salvage Co.

As another example of the possible saving through salvaging, consider the case of the pile of tools shown in the heading illustration, which were salvaged by the Goddard & Goddard Co. When new, this pile of cutters cost $232.35, and the value of the same cutters after being salvaged was $185.79. The junk value of the worn-out cutters was $14.35, and the cost of recutting was $43.68. This means that $142.11 was saved by salvaging the tools instead of selling them for junk. In all cases where the salvaging proposition is receiving consideration, particular attention is called to the fact that in addition to the actual saving in dollars and cents, there is the added advantage of being able to secure a quicker delivery on tool orders. This is a matter of great importance at the present time, because both the supply of tool steel and the services of toolmakers are inadequate to meet the demand. Tools can be salvaged ready for additional service much more quickly than they can be made new.

DATA SHOWING MONEY SAVED BY SALVAGING WORN-OUT TOOLS

Name of Tool	Size When New, Inches	List Price When New, Dollars	Size When Recut, Inches	List Price When Recut, Dollars	Present Price When Recut, Dollars	Cost of Salvaging, Dollars	Saving Based on List Price, Dollars	Saving Based on Present Price, Approximately	Weight, Pounds	Junk Value of Old Tools, Dollars
Plain Mills	3 by 2 by 1 3½ by 4 by 1¼	9.00 19.30	2½ by 2 by 1 3 by 4 by 1¼	6.90 13.80	17.25 34.50	3.60 7.72	3.30 6.08	13.65 26.78	2½ 5¾	0.55 1.27
Side Mills	8 by 1 by 1¼ 6 by ¾ by 1¼	37.30 15.35	7½ by ⅞ by 1¼ 5½ by 11/16 by 1¼	31.50 14.25	78.75 35.62	14.92 6.14	16.58 8.11	63.83 29.48	11 5/16 4	2.49 0.88
Interlocking Side Mills	6 by 1⅞ by 1½ 4 by 1¼ by 1	37.10 18.90	5½ by 1⅛ by 1½ 3½ by 1 by 1	31.50 13.90	78.75 34.75	14.84 7.56	16.66 6.34	63.91 27.19	10½ 2¾	2.31 0.61
Solid End-mills, Taper Shank	¾ by 1⅝, No. 9 t.s. 1¾ by 2½, No. 9 t.s.	3.85 8.30	9/16 by 1 7/16, No. 9 t.s. 1 7/16 by 2¼, No. 9 t.s.	2.50 6.85	6.25 17.12	1.54 3.32	0.96 3.53	4.71 13.80	1¼ 2¾	0.28 0.61
Shell End-mills	2⅜ by 2½ by 1 4¼ by 4 by 1¼	8.55 33.15	2 by 2 by 1 3¾ by 3¾ by 1¼	6.90 25.10	17.25 62.75	3.42 13.26	3.48 11.84	13.83 49.49	2⅛ 11½	0.47 2.53
Angular Cutters	2½ by ½ by ⅞ 3¼ by ½ by 1½	4.10 6.15	2½ by ¼ by ⅞ 3 by 7/16 by 1½	3.85 5.10	9.63 12.75	1.64 2.46	2.21 2.64	7.99 10.29	½ ¾	0.11 0.17
Metal-slitting Saws	3 by ⅛ by 1 6 by 3/32 by 1	2.50 5.85	2½ by ⅛ by 1 5½ by 3/32 by 1	2.35 5.00	5.87 12.50	1.00 2.34	1.35 2.66	4.87 10.16	7/16 ¾	0.07 0.17
Fluted Chucking Reamers[1]	½ by 2 ¾ by 2½ 1 by 2¾ 3 by 5¼	5.25 7.25 11.00 90.00	½ by 2 ¾ by 2½ 1 by 2¾ 3 by 5¼	5.25 7.25 11.00 90.00	13.12 18.12 27.50 225.00	2.63[1] 3.63[1] 5.50[1] 45.00[1]	2.62 3.62 5.50 45.00	10.49 14.49 22.00 180.00	¼ ¾ 1½ 4¾	0.05 0.17 0.33 1.05

Machinery

[1] Cost of salvaging is 50 per cent of list price when new.

Solving the Tool Salvage Problem

The practice of several manufacturers who have worked out the best solution of their tool salvage problem is as follows: A regular tool salvage desk is established and every requisition for tools is routed to pass over this desk before going to the purchasing department. At the time the requisition comes to the tool salvage desk, reference is made to a

card index which shows a daily inventory of all worn-out tools that are in stock. An experienced mechanic is placed at the tool salvage desk, and it is his duty to pass on every requisition for tools and compare it with the inventory of worn-out tools, in order to see whether it is not possible to fill the requisition by salvaging some of the worn-out tools that are on hand. In some plants the man at the tool salvage desk is placed on a bonus basis in order to encourage him to make a showing, and where this plan is followed some remarkable results have been obtained.

There are no especial precautions to be observed in shipping tools to the salvaging shop, except in the case of sets of milling cutters which are used in a gang. In such cases the entire set of cutters should be secured together with a wire which will not be cut or broken in transit, and a tag should be attached to the cutters marked with the word "gang." The reason for this is that such a set of cutters must be salvaged with the sizes of different cutters in the set bearing the correct relationship to each other. A little thought given to the subject will show that in cases of this kind, it is the relation of the sizes of cutters to each other which is the important point, and not the actual size of the individual cutters.

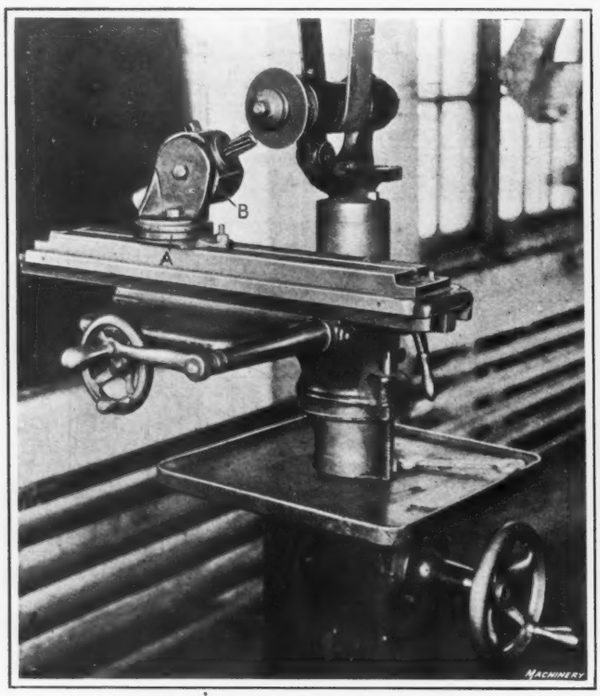


Fig. 5. F. E. Wells Tool and Cutter Grinding Machine used by Detroit Reamer Salvage Co. for End-cutting Operation on End Milling Cutters

There is one point in connection with tool salvaging to which attention should be called in order to avoid possible misunderstandings between firms which are having their tools salvaged and the management of the shops in which the work is done. This is in regard to testing tools for hardness. It is an established fact, although not as well known as it should be, that high-speed steel containing a considerable percentage of chromium will show "soft" to a file test under certain conditions of heat-treatment, although the tools which appear to be soft when tried with a file are capable of giving satisfactory service. The only reliable way to make sure that a tool is unsatisfactory is to try it out under actual working conditions; then, if the tool fails to give efficient service, there is a justifiable reason for returning it and making a claim against the shop which did the salvaging.

Discussion of Work Involved in Salvaging Cutters and Reamers

Probably a good idea of the results which are secured in salvaging various types of cutting tools, will be obtained by referring to the title illustration of this article and Figs. 1 to 4. At the left-hand side of the title illustration there is shown a group of worn-out cutters which were sent to the Goddard & Goddard Co. to be salvaged; and at the right-hand side there is shown the same group of tools after they have been salvaged. In these two groups the worn-out tool and the same tool after it has been salvaged are placed in corresponding positions, thus making it easy for the reader to appreciate just what has been accomplished in each case.

Mention has already been made of the fact that there are two possible methods of procedure in salvaging the different types of milling cutters, namely, to anneal the steel, recut the teeth and then reharden and resharpen the tool, or else to grind the teeth down ready for subsequent service without the performance of any heat-treating process. The latter is so nearly the universal method of procedure that the practice of recutting is hardly worthy of detailed consideration in this article. Where cutters are salvaged by grinding down without heat-treating, it is obvious that the original properties of the steel produced by the heat-treatment given the tool in the shop where it was made, is responsible for maintaining the tool in its original condition.

In order to give the reader a comprehensive idea of exactly what work is done in salvaging the different types of cutters, drills, and reamers, the different operations involved in salvaging several types of tools will first be tabulated in order

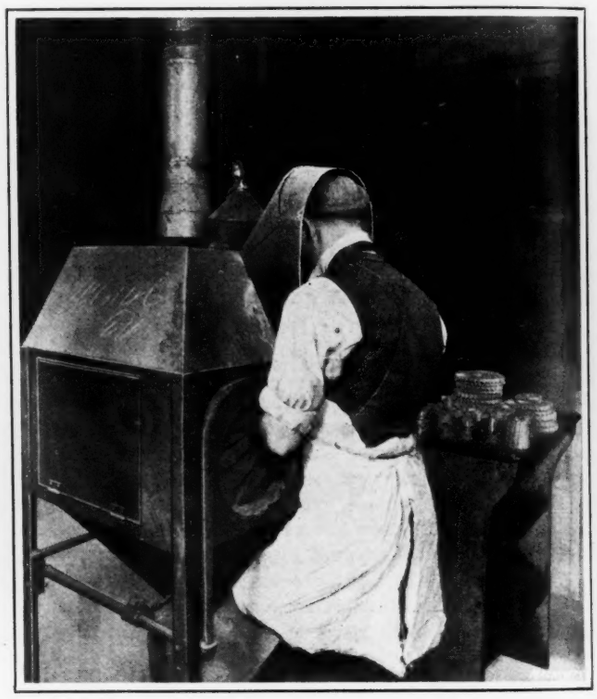


Fig. 6. View in Goddard & Goddard Co.'s Sand-blasting Room where Salvaged Tools are so treated that Workmen cannot tell them from New Tools

that those who are considering the reclaiming of their worn-out tools will better appreciate the exact amount of service which they are obtaining for the money paid to the tool salvaging concern. Many of these operations are rather ordinary examples of toolmaking practice, and so it is proposed first to make a brief reference to all of the operations, in order to show clearly the amount of work involved in salvaging the different classes of tools, and then to discuss in some detail those operations which involve the use of mechanical principles of sufficient interest to warrant their being called to the attention of MACHINERY'S readers. Many of these operations will also be illustrated, so that the reader will obtain a fairly comprehensive idea of the method of procedure.

Order of Operations in Salvaging End-mills

For the purpose of discussion, we shall consider a case in which the end-mill to be salvaged has the tang twisted off the shank, and describe the way in which the Detroit Reamer Salvage Co. of Detroit, Mich., would proceed to reclaim such a tool. The order of operations is as follows: (1) List according to original size. (2) Cut off end to remove defects in the teeth, using a Mattson cutting-off machine equipped with a vulcanite wheel. (3) Gum teeth in side flutes on a

Wilmarth & Morman universal tool and cutter grinder, the object being to thin the teeth slightly to compensate for the effect of sharpening, and also to increase the chip clearance; the machine is equipped with a soft silicate wheel and no water is employed. (4) Notch end of cutter at points corresponding to spaces between teeth, with a 1/32-inch elastic vulcanite wheel used on an F. E. Wells plain tool and cutter grinder; the reason for performing this operation is that in grinding out the tooth spaces a formed wheel is used, and the corner of this wheel cannot be kept sharp enough to produce clean corners for the tooth spaces. (5) Grind new teeth at the end of the cutter, using a formed silicate grinding wheel on an F. E. Wells plain tool and cutter grinder and performing the operation dry. (6) Grind hemispherical relief at fluted end of cutter on F. E. Wells universal tool and cutter grinder equipped with an internal grinding attachment; no water is used. (7) Back off side tooth clearance on a Wilmarth & Morman No. 2 universal tool and cutter grinder, performing the operation dry. (8) Back off ends of teeth on a Wilmarth & Morman No. 2 universal tool and cutter grinder. (9) Polish taper shank to remove surface defects, the operation being performed on an F. E. Wells speed lathe with emery cloth. (10) Slush cutter with anti-rust compound. (11) Wrap in waxed paper ready for shipment.

Fig. 5 shows the operation of cutting notches in the cutter on an F. E. Wells plain tool and cutter grinder equipped with a vulcanite wheel 1/32 inch in width, in order to provide clearance spaces in which the formed grinding wheel can grind the tooth spaces and produce sharp corners of the required form. It will be apparent from this illustration that the grinding machine is equipped with a work-holding fixture that has swivels at *A* and *B* to provide for presenting the end of the cutter to the wheel at any angle which may be desired. Otherwise, the arrangement of the equipment is standard and requires no detailed explanation. The 1/32-inch vulcanite grinding wheel is run dry, and the tool may be revolved in the fixture to bring it into the required positions for grinding successive notches.

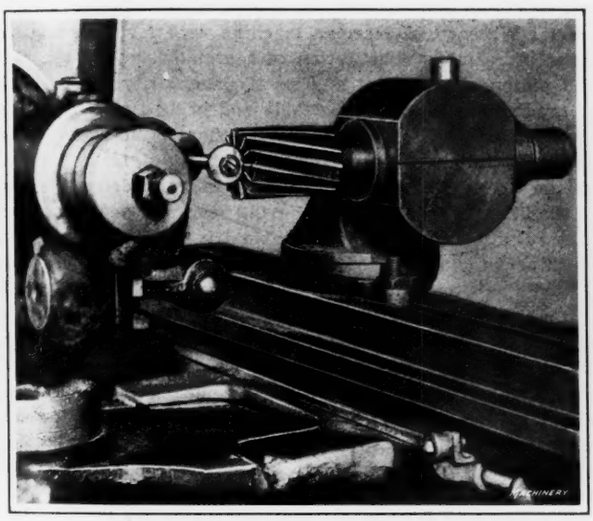


Fig. 7. F. E. Wells Tool and Cutter Grinding Machine used by Detroit Reamer Salvage Co. for grinding Hemispherical Relief in End Milling Cutters

Fig. 7 shows an F. E. Wells tool and cutter grinding machine equipped with the same work-holding fixture and work shown in the preceding illustration, but in this case the machine is set up to provide for grinding a hemispherical relief at the front end of the cutter. The grinding machine is furnished with an internal grinding attachment to drive the small wheel required for cutting the hemispherical "pocket" or relief in the cutter. This small grinding wheel is dressed to the required radius so that when the work is revolved in the fixture, provision is made for grinding the required clearance in the tool.

For backing off the ends of the teeth, the work is set up on a Wilmarth & Morman No. 2 universal tool and cutter grinder as shown in Fig. 8. It will be seen that the same work-holding fixture is employed on this machine as that shown in Figs. 5 and 7, and a spring index finger is provided to locate successive teeth in position to have the clearance ground. The work is done dry.

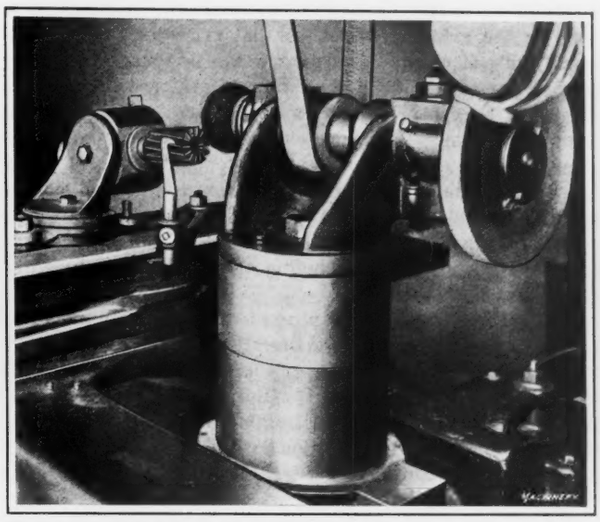


Fig. 8. Wilmarth & Morman No. 2 Universal Tool and Cutter Grinding Machine used by Detroit Reamer Salvage Co. for backing off Ends of Teeth of End Milling Cutters

Salvaging Chucking Reamers to Next Smaller Size

In taking up a discussion of the Detroit Reamer Salvage Co.'s practice in reclaiming chucking reamers, we shall consider a case in which the tang has either been twisted off the shank or at least has been so badly damaged that it is unfit for further use. In reclaiming such a reamer, the order of operations is as follows: (1) List reamer according to original size. (2) Cut off damaged tang on Mattson cutting-off machine equipped with an elastic vulcanite wheel. (3) Center-drill the tang end on F. E. Wells centering machine. (4) Cut off part of fluted end, if ends of teeth are damaged, on Mattson cutting-off machine equipped with elastic vulcanite wheel. (5) Grind 60-degree male center on fluted end of reamer, this operation being performed on a special grinding machine equipped with a formed wheel. (6) Straighten reamer on P. A. Gier straightening press and test straightness with dial indicator. (7) Mill new tang on reamer, holding work in special fixture mounted on lathe carriage and driving milling cutters on arbor between centers. (8) Rough-grind diameter of fluted end within 0.010 inch of standard size on redesigned Ott plain cylindrical grinding machine. (9) Grind relief between fluted end and taper shank on Ott No. 8 plain cylindrical grinding machine, equipped with special Norton grinding wheel which is adapted for grinding both high-speed and machine steel with satisfactory results. (10) Grind tapered shank to new finish on Modern universal grinding machine, and test work with Morse taper gage, using Prussian blue to assure accuracy of 0.0005 inch for taper fit. (11) Gum flutes on redesigned Wilmarth & Morman surface grinder to provide original amount of chip clearance; the machine is equipped with a formed wheel that engages all around the flute and is flooded with grinding compound to cool the wheel and work. In performing this operation one flute is finished at a time. (12) Finish-grind fluted end to required diameter on Brown & Sharpe No. 10 plain cylindrical grinding machine, the limit of accuracy on this operation being 0.0002 inch. (13) Grind side tooth clearance on Norton tool and cutter grinding machine. (14) Grind 45-degree end cutting clearance on Norton tool and cutter grinding machine. (15) Test diameter with micrometer caliper. (16) Mark salvaged size of reamer and salvage firm's name on Dwight Slate marking machine. (17) Slush with rustproof oil. (18) Wrap in waxed paper ready for shipment.

In salvaging a chucking reamer where the ends of the teeth have been damaged so that it is necessary to cut off a portion of the fluted end, it will at once be obvious that the center hole is ground away, and as a result, there is no provision for

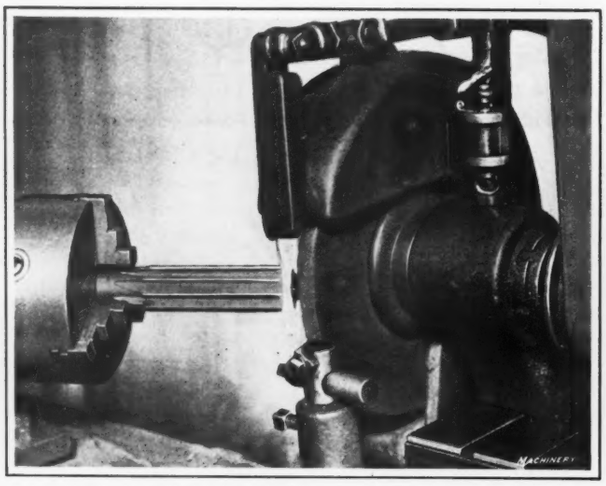


Fig. 9. Special Grinding Machine used by Detroit Reamer Salvage Co. for grinding Male Center on End of Chucking Reamers

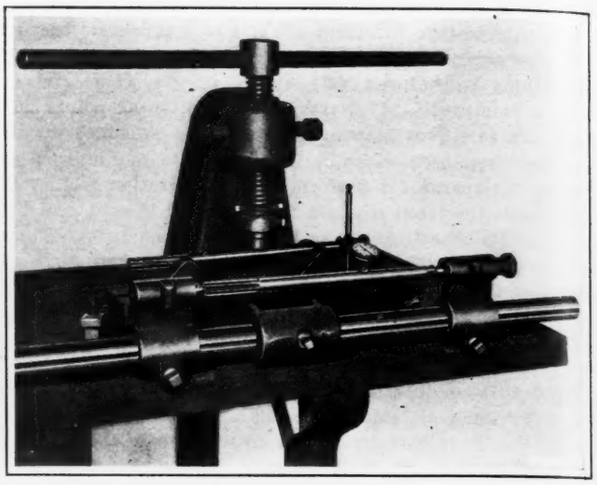


Fig. 10. P. A. Gier Straightening Press used in Shop of Detroit Reamer Salvage Co. for straightening Chucking Reamers

holding the reamer between centers ready for the performance of subsequent operations required in the process of reclaiming the tool. To overcome this trouble, the Detroit Reamer Salvage Co. use a special grinding machine equipped with a Cushman three-jaw chuck which holds the reamer at an angle to the grinding wheel, so that the wheel may be fed across the end of the reamer from the periphery to a point close to the center, to produce a male center on the reamer which fits a corresponding female center used on grinding machines for the performance of those subsequent operations where it is required to hold the reamer between centers. It will be seen that provision is made for delivering lubricant to the wheel and work during the performance of this grinding operation. Fig. 9 shows the special grinding machine equipped with a formed wheel for grinding the 60-degree male center on the end of the reamer.

The next operation in the process of salvaging reamers according to the practice of the Detroit Reamer Salvage Co., is to transfer the work to a P. A. Gier straightening press on which the reamers are tested with a dial test indicator to assure that they are perfectly straight, and if any error is discovered, the necessary correction is made until the accuracy of alignment is within 0.001 inch. Fig. 10 shows the straightening press in operation.

For gumming the teeth of reamers to provide the same amount of clearance as was originally allowed for the escape of chips, the reamer is set up between centers on a redesigned Wilmarth & Morman surface grinder, as shown in Fig. 11. This machine is of essentially standard design, except that a crank drive is provided for reciprocating the table instead of using the rack and pinion drive ordinarily furnished on the machine. The reason for making this change is that with a rack and pinion drive there is an appreciable amount of shock at each end of the stroke where reversal takes place, and this may result in leaving grinding marks on the reamer. On the special Wilmarth & Morman machine used for gumming the flutes of reamers, substitution of a crank drive for the rack and pinion arrangement enables the angularity of the crank to gradually slow down the table and bring it to a stop and then gradually accelerate it, so that there is no shock at the points of reversal and no tendency to leave grinding marks on the work. The arrangement of this crank drive is shown in the illustration, the guards having been removed from gears *A* and *B* in order to expose the table driving mechanism of the machine. Connected to the far side of gear *B* there is a slotted disk *C* in which an adjustable crankpin may be secured in the desired position to give the necessary crank throw and consequent traverse for the reciprocating table. The grinding wheel used to gum the flutes in the reamers is formed to give a full contact all of the way around one flute, and both the wheel and the work are flooded with a copious supply of grinding compound in order to cool the wheel and work, and thus prevent the steel from being burned. The gumming of one flute is completely finished before the work is indexed to bring the reamer into position for grinding the next flute.

Obviously, the finish-grinding of the diameter of the fluted end of the reamer is an operation for which the greatest accuracy is necessary, because the accuracy of holes finished with the reamer is dependent upon the precision attained in the performance of this operation. The limit of accuracy

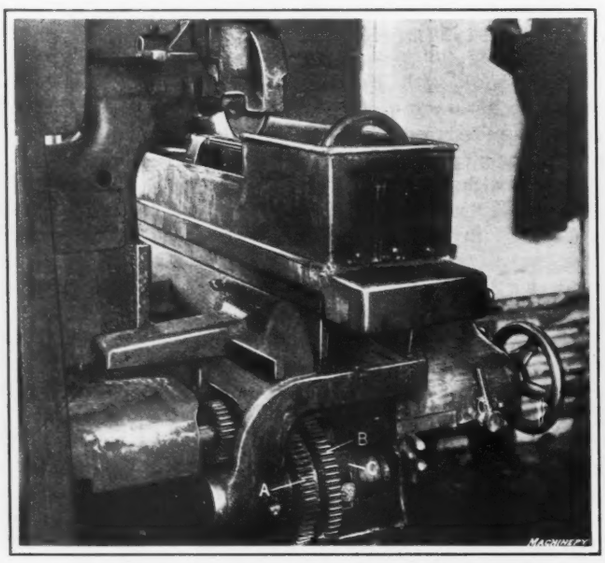


Fig. 11. Redesigned Wilmarth & Morman Surface Grinding Machine used by Detroit Reamer Salvage Co. for gumming Flutes of Chucking Reamers

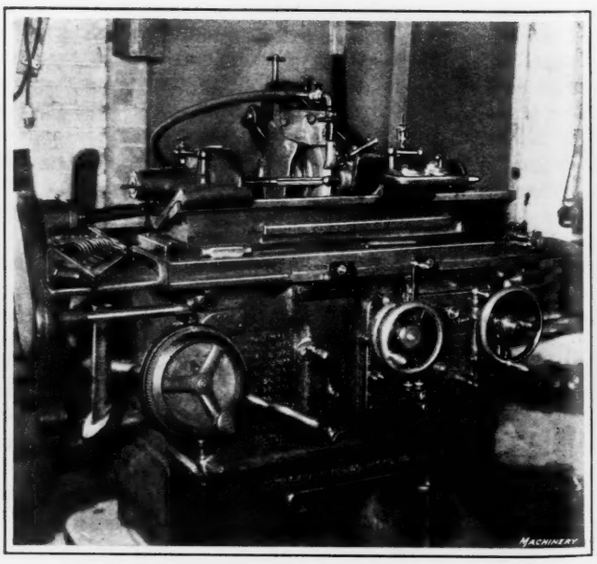


Fig. 12. Brown & Sharpe No. 10 Plain Cylindrical Grinding Machine used by Detroit Reamer Salvage Co. for finish-grinding Chucking Reamers to Diameter

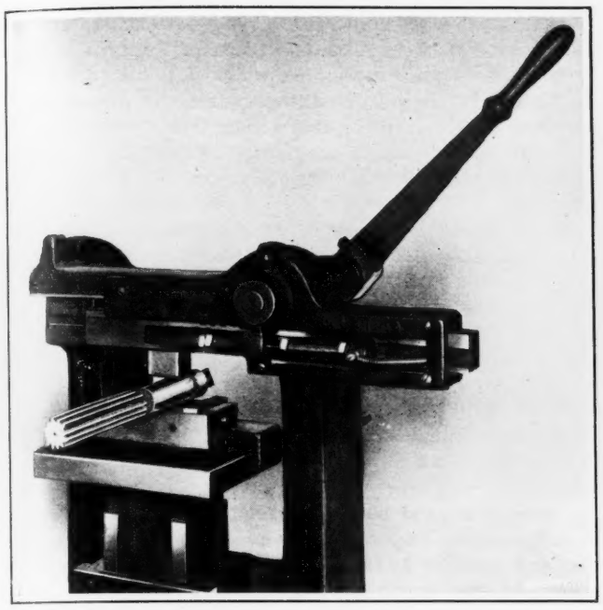


Fig. 13. Dwight Slate Marking Machine used by Detroit Reamer Salvage Co. for marking New Size on Shank of Chucking Reamers

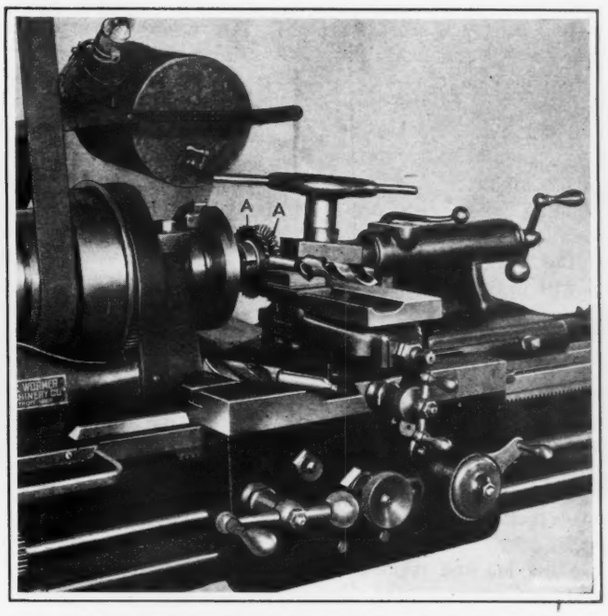


Fig. 14. Engine Lathe equipped with Special Work-holding Fixture and Form Tools for milling New Tang on Shank of Twist Drills

required is 0.0002 inch; this result the Detroit Reamer Salvage Co. obtain with a Brown & Sharpe No. 10 plain cylindrical grinding machine. The set-up for this operation is shown in Fig. 12, in which it will be apparent that the water guards have been removed in order to show the work.

For marking the salvaged size on the reamer, and also stamping it with the name of the firm that did the salvaging, use is made of one of the Dwight Slate marking machines built by the Noble & Westbrook Mfg. Co. of Hartford, Conn. Those who are familiar with this machine know that a die is used on which the desired marking is cut in relief, so that the work may be rolled under the die with the application of sufficient pressure to impress the marking. This machine is shown in Fig. 13 engaged in marking a reamer.

Practice Observed in Salvaging Twist Drills

For the sake of discussion we shall consider the case of a drill which has the tang twisted off, the cutting edges chipped, and the periphery somewhat worn, and outline the order of operations necessary in salvaging such a drill to bring it back into condition for further service. This order of operations is as follows: (1) List drill according to original size. (2) Cut off damaged tang on Mattson cutting-off machine equipped with a 12-inch elastic vulcanite wheel. (3) Drill center in cut-off end of shank on F. E. Wells centering machine. (4) Resharpen point by hand on F. E. Wells plain tool and cutter grinding machine. (5) Test straightness of drill on P. A. Gier straightening machine equipped with dial test indicator, and straighten if necessary. (6) Mill new tang with drill held in fixture on carriage of engine lathe and milling cutters mounted on arbor between centers. (7) Rough-grind diameter of fluted end within 0.005 inch of required size on Modern No. 2 universal cylindrical grinding machine equipped with special chuck to hold point of drill. (8) Finish-grind fluted end to required diameter on Brown & Sharpe cylindrical grinding machine, holding work to within 0.0002 inch of required diameter and providing a back taper of 0.001 inch per inch. (9) Grind side clearance on F. E. Wells cutter grinder equipped with special fixture for holding drill in required relation to wheel and rotating drill as it is moved across face of wheel. (10) Measure diameter of drill with micrometer caliper. (11) Mark salvaged size and salvage company's name on Dwight Slate marking machine. (12) Slush with anti-rust oil. (13) Wrap in waxed paper ready for shipment.

Fig. 14 shows the engine lathe set up for milling a new tang on the drill shank. Referring to this illustration, it will be seen that the drill is secured in a work-holding fixture carried on the lathe carriage. This carriage is disconnected from the longitudinal feed, but the cross-feed is employed to

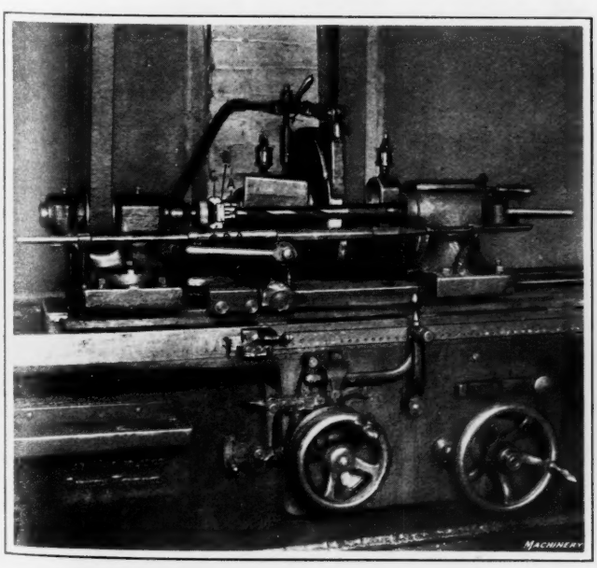


Fig 15. Modern Tool Co.'s Grinding Machine with Special Chuck, used by Detroit Reamer Salvage Co. for rough-grinding Fluted End of Twist Drills

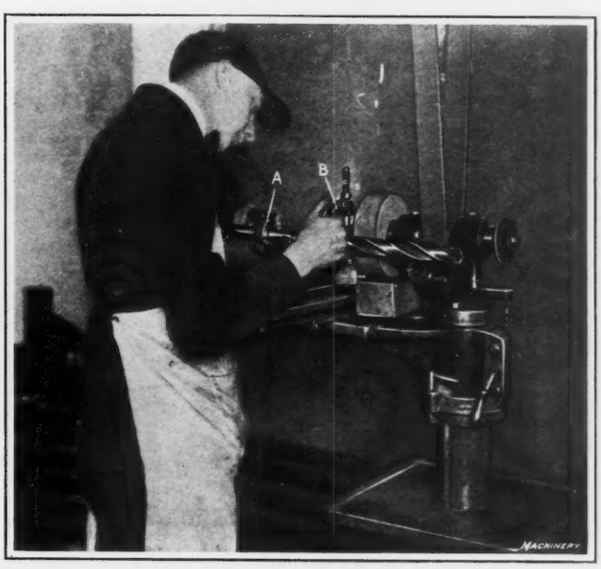


Fig. 16. F. E. Wells Cutter Grinding Machine equipped with Fixture for grinding Side Clearance on Twist Drills in Shop of Detroit Reamer Salvage Co.

feed the end of the drill shank between two form milling cutters *A*, which are carried on an arbor with the necessary space between them to provide for milling a tang of the required size on the work. This simple arrangement enables the operation to be performed very rapidly and with the required degree of accuracy.

For rough-grinding the fluted end of the drill to the required diameter, use is made of a Modern No. 2 universal grinding machine which is equipped with a special chuck, shown set up on the machine in Fig. 15, for gripping the point of the drill; the shank end is held on an ordinary center. It will be seen that this chuck has two small jaws *A* that enter the flutes of the drill at each side of the point and serve as a substitute for the usual form of center used for holding work on a cylindrical grinding machine. These jaws are pivoted at *B* and they are furnished with extensions *C* that run back on the tapered body of the chuck, so that when the body is screwed up to force the tapered end between the ends of jaw extensions *C*, jaws *A* secure a firm grip on the drill. The Detroit Reamer Salvage Co. have been granted a patent on this chuck. Aside from the use of this special chuck on the grinding machine, the operation is an ordinary cylindrical grinding job and requires no discussion.

For grinding the side clearance on the drill, use is made of an F. E. Wells cutter grinder, equipped with a special fixture as shown in Fig. 16. It will be seen that this fixture serves the double purpose of holding the drill in the required relation to the grinding wheel to grind the clearance surface and of rotating the drill as it is drawn across the face of the wheel, so that a uniform clearance surface is provided for the entire length. A ball bearing *A* is pressed lightly onto the tapered shank of the drill so that the operator can hold the outer race of this bearing comfortably in his hand while he draws the drill across the face of the grinding wheel and causes it to rotate. This rotation of the drill is accomplished by means of a pin carried by yoke *B* of the work-holding fixture, which enters the spiral flute of the drill and as the latter is drawn across the face of the grinding wheel, it necessarily causes the drill to rotate. It will be apparent that the required side clearance is obtained by having the axis of the twist drill located at a level slightly below the axis of the grinding wheel.

Miscellaneous Operations in Salvaging Milling Cutters

In the following illustrations there are shown methods used by the Goddard & Goddard Co., of Detroit, Mich., for performing various operations which are involved in salvaging different types of milling cutters. It will, of course, be understood that these are merely typical operations and that they do not in any sense tell the story of the work which is involved in placing a worn-out cutter back into condition for service.

Fig. 17 shows the work of gumming out the tops of the teeth of a side milling cutter, and standing on the table beside the centers that support the work there will be seen one of the cutters which has been completely ground. It will be apparent from this illustration that the grinding wheel is formed to engage all of the way around the space between two adjacent teeth, so that as the cutter is traversed back and forth under the wheel, the entire space is ground. It will also be seen that the customary form of spring-finger *A* is used to index the cutter for the performance of successive grinding operations. The entire set-up of the work is clearly shown in the illustration, and no further reference is necessary except to call attention to the exhaust hood *B* which carries grindings and abrasive away, and assures against the creation of conditions that would be detrimental to the health of the machine operator. All machines in the shop of the Goddard & Goddard Co. are equipped with these air hoods.

Fig. 18 shows a Wilmarth & Morman plain surface grinder set up for gumming the side teeth of the same type of cutter as is shown having the tops of the teeth ground in Fig. 17. Here it will be seen that the grinding machine is equipped with a special fixture for holding the cutter. It will be noticed that this fixture is furnished with three swivels *A*, *B* and *C*, which enable the arbor carrying the cutter to be set at any desired angle for grinding the side teeth. A spring index finger *D* is employed to index the cutter for successive grinding operations, and as in the previous case, the grinding wheel is so formed that it comes into contact with the work all of the way around the space between two adjacent teeth.

Everyone who has had experience in serving workmen who come to the window of a tool-crib to get the necessary cutters, etc., for handling their work, knows that disputes often arise between the tool-crib attendant and workmen,

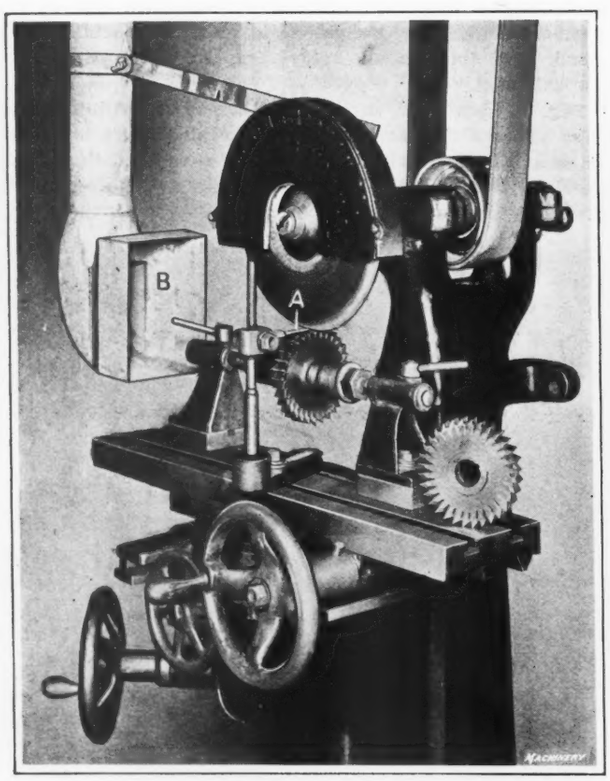


Fig. 17. Wilmarth & Morman Plain Surface Grinding Machine equipped for gumming Tops of Teeth of Side Milling Cutters in Shop of Goddard & Goddard Co.

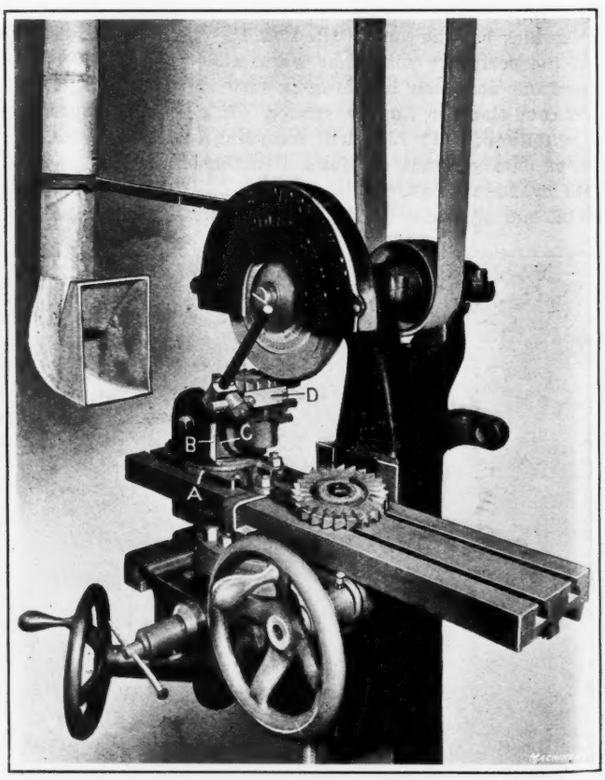


Fig. 18. Wilmarth & Morman Plain Surface Grinding Machine equipped for gumming Sides of Teeth of Side Milling Cutters in Shop of Goddard & Goddard Co.

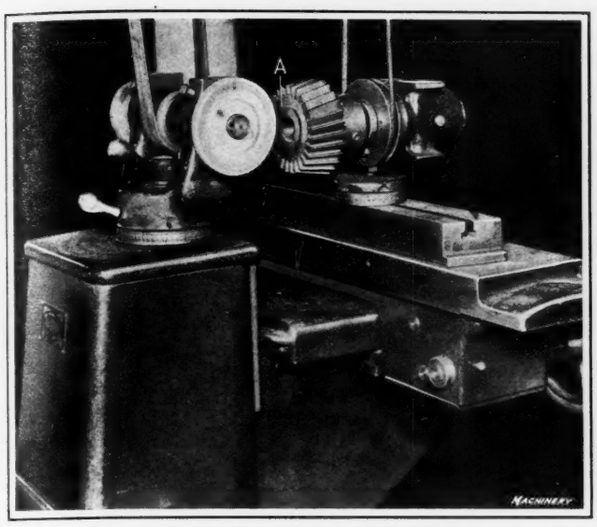


Fig. 19. Grinding Relief A on End of Angular Milling Cutter in Shop of Goddard & Goddard Co. Cutter revolves while being ground, thus making Operation Continuous

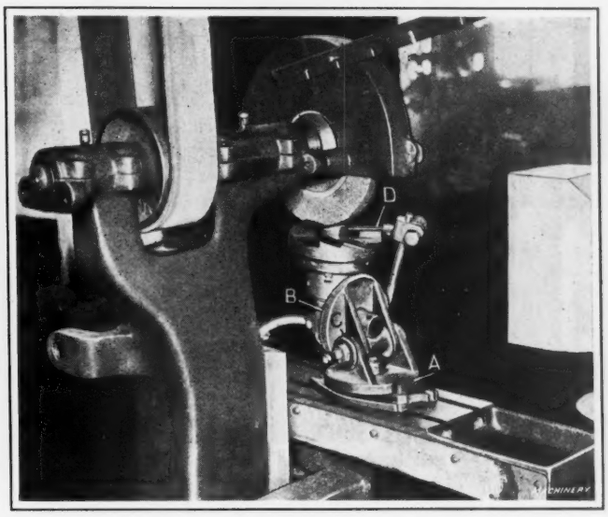


Fig. 20. Wilmarth & Morman Plain Surface Grinding Machine equipped for gumming Teeth of Spot-facing Cutters in Shop of Goddard & Goddard Co.

because the men feel that they are not getting the proper tools for their work, or that the quality of the tools handed them is below par. When salvaged tools first began to make their appearance in tool-cribs, workmen conceived an unjust prejudice against them, which became so strong that it was oftentimes difficult for the tool-crib attendant to get the men to take them. Two methods of procedure were adopted to overcome this trouble. One of these consisted of placing superintendents and foremen on a profit-sharing basis, so that an incentive was offered to reduce production costs as far as possible. Of course this step had far broader significance than its reference to the use of salvaged tools, but it created the necessary incentive to get the heads of manufacturing departments to see to it that salvaged tools were used wherever possible, because their value was only 40 per cent of the cost of the same tools when new, and so if a salvaged tool was broken the charge made against the department was much less than would have been the case if it had been a new one.

The other step toward overcoming the prejudice against salvaged tools, to which reference has been made, was the adoption by salvaging shops of the practice of sand-blasting the reclaimed tools before they are sharpened. In this way the tools are made to look just about as they did when new, so that when the tool-crib attendant hands an employe a salvaged tool, the man does not know the difference. In justice to salvaged tools it must also be stated that if the work of reclaiming them has been properly done, the service rendered will be as good as in the case of new tools, so that sand-blasting to give the same appearance as new is entirely legitimate. Fig. 6 shows part of the Goddard & Goddard Co.'s sand-blasting rooms.

Fig. 19 shows the operation of grinding the clearance surface *A* back of the end teeth on an angular milling cutter. Here it will be seen that the grinding machine is equipped with a wheel of suitable width for grinding the required clearance without traversing the table. The cutter is held by a fixture furnished with a spindle that may be driven so that rotation of the cutter in contact with the wheel provides for grinding the required annular clearance.

Referring to the equipment of the Wilmarth & Morman plain surface grinding machine which is shown in Fig. 20 engaged in gumming the teeth of a spot-facing cutter, it will be seen that the work is supported by a fixture furnished with three swivels, *A*, *B* and *C*, which enable the cutter to be brought into contact with the wheel at any required angle. Indexing is accomplished by means of spring-finger *D*, which locates the successive teeth in position to be gummed.

Advantages of Tool Salvaging in War Time

The activity and competition in many lines of industry is now so keen that advantage must be taken of every possibility of saving, in order that this competition may be met and still leave a reasonable margin of profit after all manufacturing expenses have been paid. In war time the machine shop manager is faced with an unprecedented condition as regards both a scarcity of steel and an inadequate supply of skilled toolmakers. The demand for high-speed steel used in the production of tools for various lines of munition work has resulted in increasing the price according to the familiar principle of supply and demand; and the scarcity of toolmakers has been due both to an abnormal demand for tools and to a further depletion of the supply of men due to the draft. As a result, the provision of means for obtaining further service from cutting tools is of exceptional importance in war time, and has led many manufacturers to take advantage of this opportunity of saving, who might not have thought the incentive sufficiently great to consider the proposition in times of peace. Many of those who adopted the practice as a war measure, however, are securing such satisfactory service from their salvaged tools that there is little doubt that they will continue salvaging their high-speed steel cutting tools as a proved method of economy which is equally applicable in times of war and of peace.

* * *

PACKING FOR EXPORT

The American Consul General at Rio de Janeiro reports that in a shipment of 2000 cases arrived at the Brazilian port from the United States, 600 were found to be damaged. In another instance, out of 450 cases, 113 were damaged due to improper packing for export trade. Tin plate, for example, arrives from the United States in lots of 112 sheets packed in cases of very thin wood and insufficiently hooped with light iron bands. This does not provide protection against handling when the cargo is discharged, and the case is often broken, and the sheets are bent and exposed to the weather conditions. The necessity for packing goods for export differently from those intended for the domestic trade has been emphasized for years, but American manufacturers seem to be slow to appreciate that if we are to obtain a sufficient share of the foreign trade after the war, we must meet the foreign trade requirements as well as do other nations.

* * *

In an investigation made by the *Engineering News-Record*, four questions were put to deans and professors of engineering schools and colleges with a view to ascertaining what demands there were at the present time for graduates in civil, electrical, mechanical and chemical industries; to what extent there was any dearth or over-supply of engineers; and whether there was any apparent improvement in the status and pay of engineers. The replies obtained from a great number of educators indicate that there is a strong demand for young graduates, but no startling dearth of engineers, and that there is little or no support for the view that engineering will be particularly rich in financial reward.

MACHINING A NOSED-IN SHELL[1]

BY M. H. POTTER[2]

Many shops have had considerable trouble machining nosed-in shells. This trouble is due to the method used rather than to the machine tool equipment. The method described here, though having more operations than most methods, has been found very satisfactory in a number of large factories. While the operations given are those for a six-inch British high-explosive shell, the method is adapted to any kind of nosed-in shell; the gaging instructions are also worthy of careful study. The shell is in a horizontal position, except during the tenth, twenty-second, and twenty-third operations, when it is vertical.

Operation 1—Cut off open end; gage depth of bore.

Operation 2—Center; gage depth of center.

Operation 3—Rough-turn; gage diameter.

Operation 4—Bore; gage diameter and depth of bore.

Operation 5—Face base, rough; gage thickness of base.

Operation 6—Recenter; gage depth of center.

Operation 13—Finish-turn; gage diameter of body and nose and profile of nose.

Operation 14—Thread nose; gage diameter of threads.

Operation 15—Weigh; make allowances for weight of stock removed in following operations, the weight being determined by actual trials.

Operation 16—Bore out base and form head; gage diameter, depth of bore, and form of head.

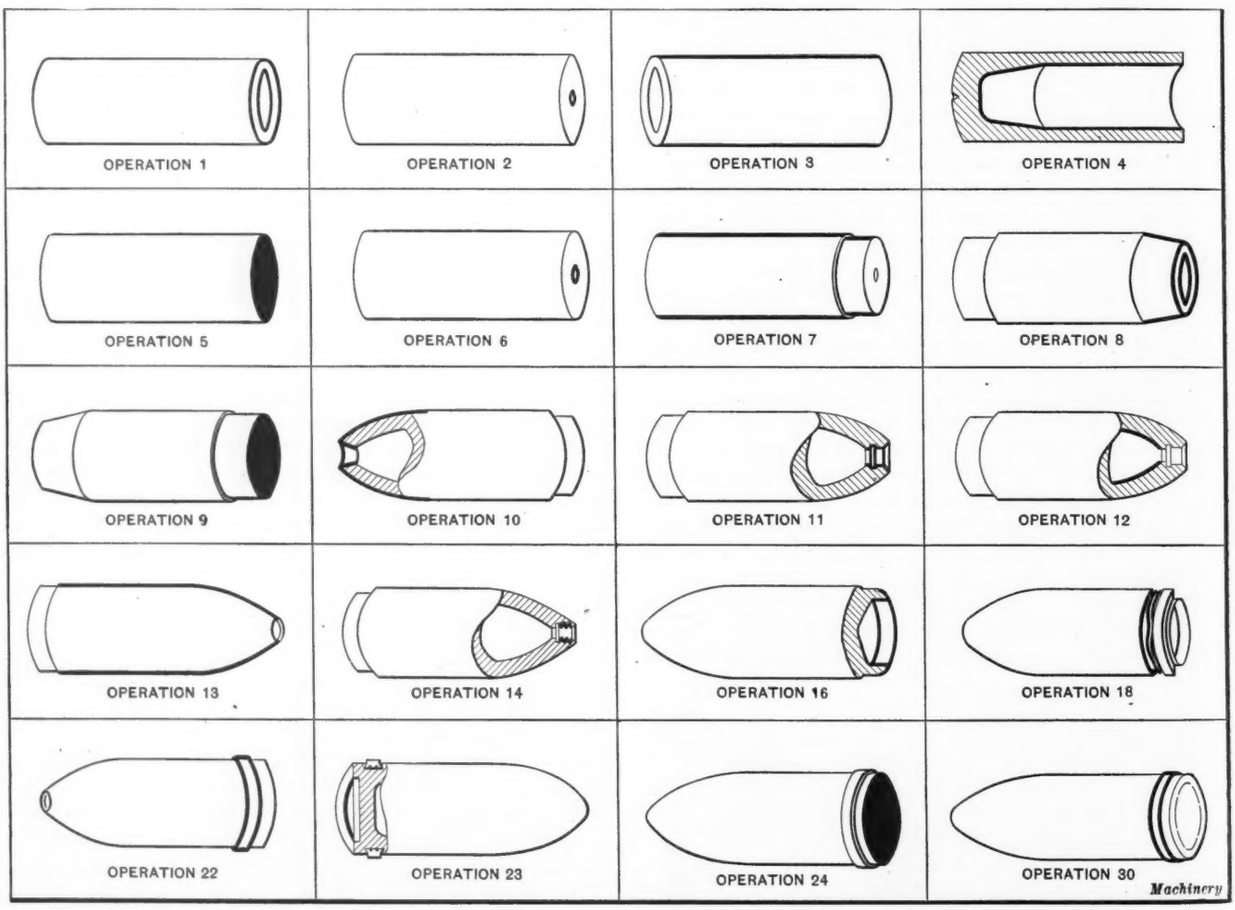
Operation 17—Check weight to determine that shell is within the required weight at this stage.

Operation 18—Groove and wave; gage width and diameter of groove and distance from base; also diameter and height of ribs and angle of under-cut.

Operation 19—Sand-blast interior; wash and clean exterior.

Operation 20—Preliminary shop inspection. After collecting shells in series, gage diameter of body, base, and groove in body, width of groove, distance from base, and thickness of walls and base.

Operation 21—Preliminary government inspection.



Machining Operations on 6-inch British High-explosive Shell (Heavy Lines and Solid Black Surfaces indicate Machining Operation)

Operation 7—Rough-turn body a second time and finish base diameter to size; gage diameter of body and base and width of base diameter.

Operation 8—Bevel and face open end to length; gage form of bevel and over-all length of shell.

Operation 9—Reface base; gage thickness of base.

Operation 10—Nose in; gage over-all length of shell, outside diameter at nose, profile of nose, diameter of hole in nose, and thickness through nose.

Operation 11—Bore fuse hole and recess; gage diameter of fuse hole above and below recess, diameter of recess, distance from nose, and angle of fuse hole.

Operation 12—Finish inside contour; gage thickness through nose.

Operation 22—Apply band; gage diameter of band.

Operation 23—Rivet baseplate; examine for tightness.

Operation 24—Face base; gage thickness of base and radius at edge.

Operation 25—Stamp base.

Operation 26—Hand retap threads and ream angle of fuse hole; gage threads, angle of fuse hole, and thickness through nose.

Operation 27—Wash and clean inside and outside.

Operation 28—Varnish.

Operation 29—Bake varnish.

Operation 30—Turn band; gage diameter of band, form, width, and distance from base.

Operation 31—Final shop inspection; gage diameter of base, profile of nose, and concentricity of shell.

Operation 32—Final government inspection.

* * *

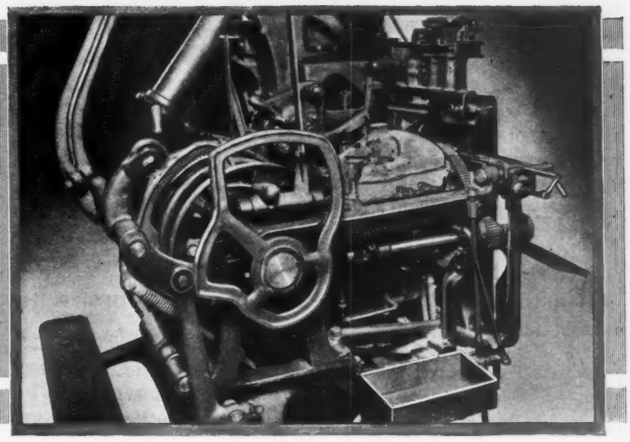
There are in use in the United States 435,000 motor trucks with an average capacity of 2.6 tons.

[1] For previous information on shell manufacture, previously published in MACHINERY, see "Manufacture of the U. S. 75-millimeter Shell," March, 1918; "Semi-automatic Shell Making Machines," November, 1916; "High-explosive Shell Manufacture," December, 1915; "The Heat-treatment and Testing of Shrapnel Shells," September, 1915; and "Shrapnel and Shrapnel Manufacture," April, 1915.

[2] Address: 1621 Queen St., W., Toronto, Ontario, Canada.

Ingenious Mechanical Movements

By Franklin D. Jones[1]



First Installment of an Article on Mechanisms for Transmitting, Modifying, and Controlling Motion to Secure Changes of Velocity, Direction, and Time of Action[2]

IN the development of new types of machines or inventions, the real problem, in many instances, is to obtain a certain motion or combination of related movements. The stresses involved or the power to be transmitted, and the proportioning of the different parts to resist the stresses without excessive distortion or breakage, are frequently of little importance when compared with the action of the machine or the mechanical movement. The designer or inventor conceives the idea of accomplishing some result by mechanical means, and the first question that arises is: How can the desired result or effect be obtained mechanically? It may be apparent from the nature of the work to be done that certain changes in the velocity of different parts are necessary, and that the direction of motion must be varied at given intervals. It may also be essential to modify the motion so that it is either irregular, intermittent, or both, with changes of action occurring at uniform or variable intervals of time. If the problem were confined entirely to mechanical action, it would be greatly simplified in many instances, but, unfortunately for the designer and inventor, it is of the utmost importance to consider the cost of manufacturing whatever machine or mechanism is being developed. If expense could be disregarded, it would be possible to do almost anything mechanically. The problem, then, is how to accomplish a certain result without employing a mechanical device which is so complex that it costs more than it is worth. Many of the most ingenious mechanisms in existence are very simple and direct in their action, although they were not all simple when first constructed. When a mechanical device is first being developed, the operation it is to perform may quite naturally overshadow the question of manufacturing cost, and frequently the simplifying or the elimination of unnecessary parts begins afterward. It is evident, however, that at the very beginning the simpler the mechanism is, the better, and failure to recognize this fact is responsible for many inventions without commercial value. The study of mechanical movements is of especial importance at the present time, owing to the increasing use of automatic and semi-automatic machinery in almost every line of manufacture. No attempt will be made in this article to present a comprehensive treatise on mechanical movements, but rather to describe a variety of mechanisms which are considered ingenious in their design and which embody valuable principles that may be applied to various other mechanical devices.

[1]Associate Editor of MACHINERY.

[2]A chapter that will be included in the author's book "Mechanisms and Mechanical Movements," to be published in the near future.

Reciprocating Motion which Automatically Varies

The first mechanism to be described is arranged to impart a reciprocating motion to a slide or bar in such a way that the length of the stroke is constantly increasing or decreasing from the minimum to the maximum, and *vice versa*. The fly frames used in the manufacture of cotton goods are equipped with a mechanism of this kind for traversing the rovings or slightly twisted slivers of cotton as they pass between the rolls of the fly frame, which is used to make the rovings more slender and give them a twist. The reason for traversing the roving as it passes between a steel and a leather-covered roll is to prevent wearing the leather covering at one place. On some machines, this reciprocating or traversing motion is obtained from a crank or a cam. This simple arrangement distributes the wear, but, if the length of traverse is uniform, the tendency is for the leather covering to wear the most at the points of reversal. In order to distribute the wear more evenly, the mechanism shown in Fig. 1 was designed. With this arrangement, the length of traverse gradually increases until it reaches a maximum and then decreases until the shortest length of traverse is obtained; the gradual increasing and decreasing of the stroke are then repeated.

The diagram *A* illustrates graphically the action obtained with a crank motion, and diagram *B* illustrates the variable stroke derived from the mechanism to be described. The guide-bar *C*, which extends the full length of the rolls, has small holes opposite each roll section through which the rovings pass, and it is this guide-bar which receives the reciprocating motion. The automatic variation of the traversing movement is derived from two eccentrics *D* and *E*, which revolve at different rates of speed. These eccentrics are formed on the hubs of gears *F* and *G*, which are adjacent to each other, and are both driven by one worm *H*, as shown by the end view. The motion of the eccentrics is transmitted to guide-bar *C* through rods *J* and *K* and the bracket *L*. One of the gears meshing with worm *H* has one more tooth than the other, which causes the gears to rotate at a varying speed. The result

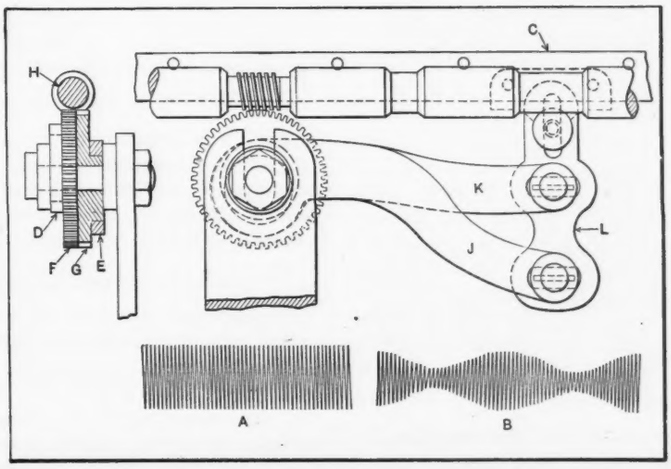


Fig. 1. Double Gear and Shifting Eccentric Combination for automatically varying Traversing Movements

is that the eccentrics formed on the two gear hubs are continually changing their position relative to each other, which automatically varies the length of traverse for guide-bar *C*. For instance, at one period during the cycle of movements, both eccentrics will move rods *J* and *K* in the same direction, and, at another period, one eccentric rod will be moving backward while the other is moving forward, thus reducing the stroke of the guide-bar. The connections between the eccentric rods and the bracket are adjustable; an adjustment is also provided where the bracket is attached to the guide-bar, so that the maximum traverse may be varied.

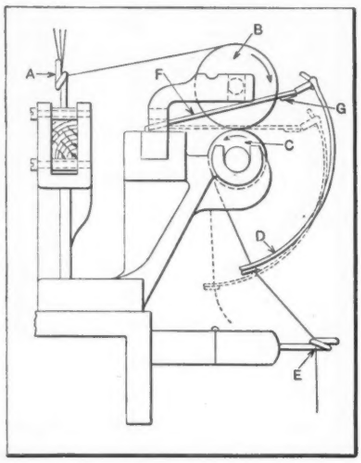


Fig. 2. Tripping Device for Textile Machine

Automatic Tripping Devices for Textile Machines

Some very ingenious tripping mechanisms or "stop motions" are applied to different classes of textile machines. The examples described illustrate the possibilities of the use of comparatively simple devices for automatically controlling the action of machines under conditions which might, at first, seem to be very complex and difficult.

The stop motion shown in Fig. 2 is applied to a machine used for twisting yarn. The yarn passes from the guide wire at *A* around the rolls *B* and *C*, through an eye in wire *D*, and out through the guide at *E*. The wire *D* is attached to another wire *F*, which is normally held by the yarn in the position shown by the full lines. If the yarn or thread should break, the wires fall to the position shown by the dotted lines, thus bringing wire *F* into engagement with the lower roll *C*. Contact with this roll immediately moves the wires to the left until a tongue *G* enters between the rolls and raises *B* out of contact with *C*, which prevents it from revolving and stops the delivery of yarn.

Another stop motion which acts when a thread is broken is shown in Fig. 3. This mechanism is applied to a machine used for winding thread on spools. It is designed to raise the spool out of contact with a flange which drives it by friction, if a thread breaks, thus arresting the motion of the spool without stopping the spindle on which the spool is mounted. The device is also arranged so that the wire which drops when a thread breaks is raised automatically to its normal position for rethreading. The thread *A* passes through the eye of a drop wire *B* and serves to hold this wire in its normal position. Attached to this wire there is a lever *C* pivoted at *D* and connected by link *E* with the catch *F*. The lever *G* is normally held in a horizontal position by catch *F*. If a thread breaks, the dropping of wire *B* releases catch *F* and lever *G* falls to the position shown in the illustration. This lever is connected by a rod *H* with a sleeve *J* pivoted at *K*. The downward movement of lever *G* swings the sleeve *J* about its pivot and brings a pin under the flange *R* of the spool, thus raising it from the supporting disk *L*, as shown in the illustration; at the same time, the flange of the spool engages a rubber disk *M* which stops the rotation. Attached to the shaft of lever *G*, there is a small finger *O* which is given a partial turn when the catch lever falls. As the result of this movement, the finger engages lever *C* and swings it with the drop wire *B* back to the normal position for rethreading. As soon as the catch lever has been engaged again with the catch *F*, the spool drops into contact with its driving flange and again begins to wind the yarn.

Automatic Trip for Wire-winding Machine

Fig. 4 shows an automatic tripping device that is applied to a machine used for winding small wire onto spools. In this illustration, *A* represents the reel which contains the stock of wire, and *B* is the spool upon which the wire is wound. This spool is driven at a constant speed. If, for some reason, the wire should not uncoil easily from reel *A*, it might be broken or the mechanism damaged, assuming that the wire passed directly from the reel to the spool. In order to avoid trouble from any resistance to uncoiling which may occur, the wire, after leaving the reel, is guided by idler pulleys, so as to form a loop; at the end of this loop there is an idler pulley *C* mounted on a lever *D*, which is free to swing about fulcrum *E*. When the uncoiling and winding is proceeding under normal conditions, the weight of lever *D* is sufficient to prevent the wire from lifting it; any abnormal resistance, however, such as might be caused by a kink on reel *A*, will result in swinging lever *D* upward into contact with trip *G*, which, by disengaging a clutch, stops the machine.

Electro-mechanical Tripping Device

Certain classes of textile machines are equipped with some form of electrical control for automatically stopping the machine when it is operating under abnormal conditions. A simple method of controlling a machine electrically is found on some drawing frames. The upper and lower sections of the machine frame are insulated from each other, and one pole of a small dynamo is connected to one frame section and the other pole to the other section. The cotton, which is a non-conductor and is constantly passing between the different pairs of rolls, prevents the completion of the electrical circuit except when the cotton breaks and both rolls of a pair come directly into contact with each other. When this occurs, the electrical circuit thus formed, acting in conjunction with an electro-magnet, swings a lever into the path of a revolving trip or catch, which, as its rotation is stopped, either shifts a belt from the tight to the loose pulley or disengages a clutch by means of suitable mechanism.

A very simple form of electro-mechanical device is shown in Fig. 5. This is applied to looms and operates whenever a thread breaks. The steel spring wire *A* is normally held between two threads in the bent position shown to the left. If one of the warp threads should break, the spring wire is immediately released and flies over to the left into engagement with rod *B*, as shown to the right, thus closing an electrical circuit. This circuit is a comparatively weak one and stops the machine by means of an electro-mechanical type of mechanism. The actual force required for stopping the machine is sometimes considerable, and it is derived by a moving part of the loom, the electrical mechanism being used simply to cause a locking effect that enables the other part of the mechanism to operate.

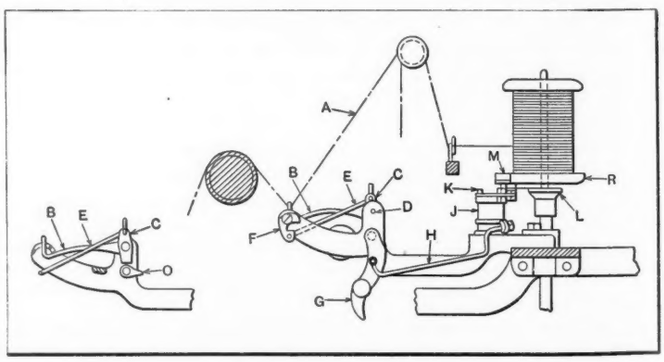


Fig. 3. Another Tripping Device or Stop Motion for Textile Machine

Automatic Speed-limiting Devices for Engines

A speed-limiting device which is governed by the inertia of a weight and the tension of a spring is shown in Fig. 6. This automatic stop was designed for application to steam engines, but devices operating on the same general principle could doubtless be applied to other classes of machinery. This mechanism is primarily a safety device and is intended to stop the engine and prevent damage such as might be caused by a bursting flywheel, in case the governor failed to operate. The

lever *A* is pivoted at *B* to the engine cross-head and is normally prevented from swinging about pivot *B* by the spring *C* attached near the upper end. The inertia of weight *D*, which may be adjusted along the lever *A* tends to swing the lever to the right when the motion is suddenly reversed and the cross-head moves to the left. When the cross-head is at one end of its stroke, the upper end of lever *A* is quite close to the catch *E*, which engages latch *F*. Rod *G* attached to this latch connects through whatever additional rods or levers may be needed, with the tripping mechanism used in conjunction with a quick-closing valve which controls the flow of steam to the engine cylinder. This valve and its operating mechanism is shown in detail at the left of the illustration. Rod *G* is connected in any convenient way with bellcrank lever *H*, from which rod *J*, carrying weights at its lower end, is suspended. This rod passes through trip-lever *K*, which normally engages lever *L* connected with the quick-closing valve *M*. If, for any reason, the speed of the engine becomes excessive, the lever *A* and its attached weight resists the sudden reversal of motion at the end of its stroke sufficiently to overcome the tension of spring *C*, and lever *A* strikes catch *E*, thus releasing latch *F*; as rod *J* drops, the flange on it strikes trip *K* and allows the steam valve to be closed by the weighted lever *N*. This speed-limiting device may be adjusted by varying the tension of spring *C* and also by changing the position of weight *D*. The greater the spring tension and the nearer the weight is to the pivot *B*, the faster the speed will have to be to overcome the tension of the spring at the point of reversal. The handle *O* is for resetting the steam valve, and handle *Q* for tripping the valve by hand. If remote control is required, this may be obtained by the use of rods or cables directly connected to latch *K*, or by the use of a solenoid *R*, as indicated by the illustration. This automatic safety stop is recommended as being simple, positive in action, adjustable, inexpensive, and easily applied to almost any engine.

The automatic speed-limiting device described in the following was designed for application to gas or gasoline engines. In case the speed becomes excessive, owing to the failure of the governor, this tripping mechanism, which is of the centrifugal type, operates by breaking the ignition circuit. It may be attached either to the secondary shaft or to the main shaft. The controlling element is a weight *A*, Fig. 7, which is attached to a rod connecting with a spring *B* on the opposite side of the hub. This weight is located within a casing *C* carried by a stud *D* screwed into the end of the shaft. Pivoted near the casing is a latch *E* which normally holds the weighted trip-lever *F* in the position shown. The ignition switch is located at *G*, and when lever *F* is held up by latch *E*, the ignition circuit is closed. If the speed of the engine is increased to such an extent that the action of centrifugal force causes weight *A* to fly outward against the tension of spring *B*, the end of rod *H*, by striking catch *E*, releases lever *F* and allows it to fall, thus breaking the ignition circuit.

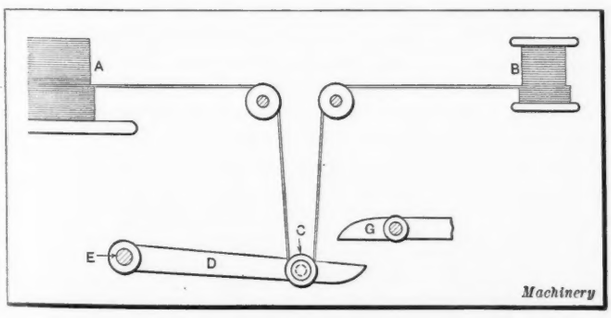


Fig. 4. Safety Tripping Device for Wire-winding Machine

Automatic Ratchet Reversing Mechanism

The simple design of ratchet reversing mechanism illustrated in Fig. 8 enables a ratchet wheel to be automatically reversed after making a predetermined number of revolutions, and the arrangement is such that the time of reversal or the number of revolutions made by the driven ratchet prior to reversal may be varied at will throughout a wide range. The double pawl *A* is carried by an oscillating arm, and this pawl engages the driven ratchet *B*. Mounted concentrically with *B* there is a smaller controlling ratchet *C*, which is normally restrained from rotating by suitable frictional resistance. The larger diameter of ratchet *B* prevents pawl *A* from engaging the smaller ratchet *C*, except when the deep notch *D* is reached by the pawl, which then drops down into engagement with *C*.

The reversal of motion is effected by the engagement of the extension on pawl *A* with one of the trip-dogs *E*. The view to the right shows the pawl at the point of reversal. The number of revolutions made by ratchet *B* prior to reversal depends upon the number of deep notches *D* and the position of the trip-dogs *E*. When this mechanism is in operation, ratchet *B* receives an intermittent motion from the oscillating pawl *A*, and the controlling ratchet *C* remains stationary until one of the deep notches *D* is engaged by pawl *A*; then ratchets *B* and *C* rotate together an amount depending upon the motion of the pawl. Controlling ratchet *C* then remains stationary until another deep notch is engaged. The repeated movements of ratchet *C* each time the pawl drops into a deep notch finally bring one of the trip-dogs *E* into contact with the projection on the pawl; the latter is then swung around so that its opposite end engages ratchet *B*, and, consequently, the direction of rotation is reversed. The time of reversal may be controlled by varying the distance between the trip-dogs and by having one or more deep notches in the driven ratchet.

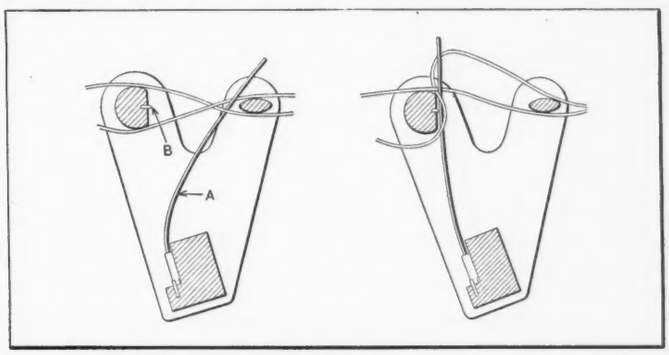


Fig. 5. Simple Form of Electrical Control for stopping Loom when Thread breaks

Automatic Variation in Point of Reversal

One of the many interesting mechanisms found on textile machinery is the one employed on fly frames for controlling the winding of the roving on the bobbin. The speed of the bobbins, in revolutions per minute, is decreased gradually as the continued winding of the roving increases the diameter, so that the peripheral speed remains practically constant. As the bobbins revolve, they are given a vertical reciprocating motion, in order to wind the roving onto them in successive helical layers. This winding of the roving onto the bobbin involves, in addition to decreasing the speed as the diameter increases, a decrease in the traversing speed of the bobbin and a gradual shortening of the bobbin travel as one layer of roving is wound upon another. The bobbin should move a distance equal to the diameter of the roving while it rotates relative to the "flyer" a distance equal to one revolution; therefore, as the bobbin speed gradually diminishes, it is also necessary to decrease the rate of traverse, so that each layer of the roving will be coiled closely. The change in the point of reversal in order to shorten the stroke as the bobbin increases in diameter is required in order to form conical ends on the wound bobbin and a firm winding that will not unravel and cause trouble, such as would be the result of attempting to wind each layer the full length of the bobbin. These changes occur simultaneously, although they will be referred to separately in describing the "builder motion" illustrated diagrammatically in Fig. 9.

The plates *B* and *C* engage a screw *A*, which has a right-hand thread extending along half its length and a left-hand

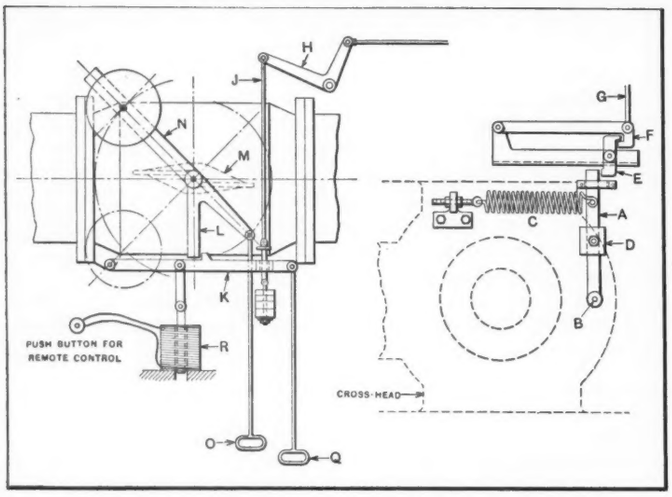


Fig. 6. Automatic Speed-limiting Mechanism for Steam Engines

thread along the remaining half. These plates and the screw are traversed vertically with the bobbin carriage. The vertical shaft *D* carries a dog *E* having two arms located 180 degrees apart. At each end of the stroke, shaft *D* makes a half turn, which motion is utilized for reversing the motion, for shifting the cone belt slightly in order to decrease the speed, and also for shortening the stroke of the bobbin. As the plates *B* and *C* move vertically, one end of the tumbling dog *E* bears against them until it slides off at one end. Prior to the disengagement of the dog with one of the plates, gear *F* on the cone-pulley shaft revolves idly in a space on the rim of gear *G* where the teeth are omitted. There are two of these spaces located 180 degrees apart, as the illustration indicates. One of the projection pins on the disk *H* at the lower end of shaft *D* is in engagement with a lever *J*, which has attached to it a spring that holds the lever against a pin and tends to turn shaft *D*. When dog *E* slides off one end of a plate, shaft *D* is turned far enough by the action of the spring and lever *J* to bring gear *G* into mesh with pinion *F*; consequently, gear *G* is revolved one-half turn, or until pinion *F* engages the space on the opposite side where there are no teeth. The partial rotation of shaft *D* shifts the reversing gears through a connection at the lower end and starts the bobbin carriage and plates *B* and *C* in the opposite direction. As the opposite end of the tumbling dog *E* swings around, it engages one of the plates and again causes a reversal of motion as it slides off the opposite end.

The shifting of the belt on the cone pulley at each reversal, for gradually decreasing the speed as the bobbin winding increases its diameter, is obtained by connecting rack *M* with shaft *D* through the pinion *N* and the train of gearing shown. This rack *M* has a fork attached to it that connects with the cone belt, and it is traversed slightly each time dog *E* slides off a plate and allows shaft *D* to turn one-half revolution. The reduction in the length of the carriage traverse is obtained by revolving screw *A* at each reversal and thus shortening the distance between the plates *B* and *C*. This rotation of the screw is effected by pinion *P*, which engages rack *M* and transmits motion through the other gears shown to the extension *Q* on the screw, which is made square and is free to slide through the gear hub as the carriage moves vertically. As the plates *B* and *C* are moved toward each other, the tumbling gear *E* has a shorter surface to traverse before it is disengaged. These two plates both move the same distance, so that the point of reversal decreases at each end and the bobbin is wound conical at both ends. The roving delivered by the front roll is either tightened or slackened by engaging pinion *R* with one of the three gears shown.

Operation of Clutches for Reversing Motion

When a reversal of motion depends upon the action of a clutch which is shifted from one gear to another revolving in an opposite direction, it is essential to operate the clutch rapidly and to secure a full engagement of the clutch teeth. Provision should also be made against disengagement of the clutch as the result of vibrations incident to the operation of the machine. There are two common methods of controlling the clutches used in connection with the bevel-gear type of reversing mechanism. One form of control may be defined as the swinging-latch type and the other as the beveled-plunger type. The general principle of operation is the same in each case, and is as follows: When the work-table, or whatever part is to be reversed, approaches the end of its stroke, a spring is compressed, and then a latch or trip allows this compressed spring to throw the reversing clutch suddenly and rapidly from one gear to the other. Reversing mechanisms of this general design are often called the "load-and-fire" type, because the spring is first loaded or compressed and then tripped to secure a rapid movement of the clutch and a reversal of motion at a predetermined point within close limits. The action of the compressed spring also insures a full engagement of the clutch teeth and prevents the clutch from stopping in the central or neutral position, which might occur if a spring were not used and the momentum of the part to be reversed were insufficient to carry the clutch across the space intervening between the two reversing gears.

The reversing mechanism illustrated in Fig. 11 is a bevel-gear type equipped with the swinging-latch form of clutch control. This mechanism is applied to a cylindrical grinding machine for reversing the motion of the work-table, and is located at the rear of the machine. The rockshaft *H* extends through to the front of the machine and has attached to it a lever which is engaged by dogs on the work-table, the distance between these dogs being varied according to the length of stroke required. At the rear end of rockshaft *H* there is a lever *G*, which, by means of link *J*, transmits motion to the reversing mechanism. As the work-table approaches the end of its stroke, lever *G* swings either to the right or the left, as the case may be. If the motion is to the left, tappet *A*, connected to link *J*, compresses spring *L* on rod *M* and forces block *D* against a square shoulder on the lower side of latch *B*. Continued movement of tappet *A* to the left causes the beveled side of *A* to lift latch *B*, thus releasing block *D*, which, with rod *M*, is thrown rapidly to the left under the impulse of the compressed spring *L*.

After the movement of shaft *M* to the left, the shoulder on latch *C* drops in behind block *E*. The fork *N* on rod *M* also throws shaft *O* to the left and with it the reversing clutch *F*, which is keyed to this shaft. The motion that prior to reversal was transmitted through bevel pinion *P* to the main gear *R* is now from pinion *Q* to *R*, so that the movement of the work-table is reversed. When the work-table approaches the end of its stroke in the other direction, tappet *A* is moved to the right, thus compressing spring *S*. Then latch *C* is lifted by the beveled edge on *A*, and the parts *M*, *N*, and *O* are quickly shifted to the right by spring *S*, thus again reversing the motion.

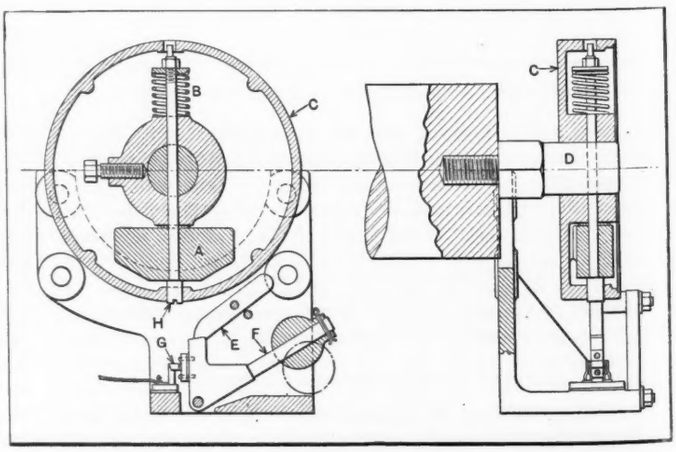


Fig. 7. Centrifugal Type of Speed-limiting Device designed for Gas or Gasoline Engines

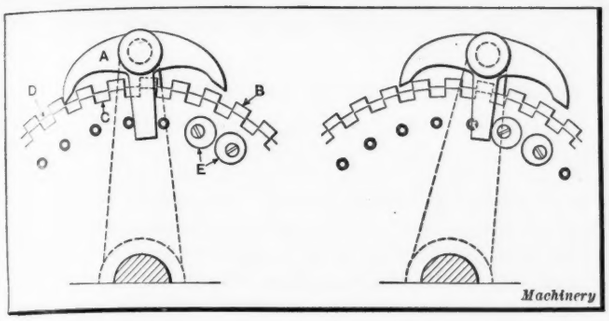


Fig. 8. Ratchet Mechanism that will automatically reverse after making a Predetermined Number of Revolutions

If the operator desires to stop the traversing movement at the end of the stroke, this may be done by the movement of a knob located in the center of the table-traversing handwheel at the front of the machine. This knob is connected with a plunger *T*, which, by pressing the knob, may be held under pressure against the reversing clutch *F*. When this clutch is shifted at the end of the stroke either by springs *L* or *S*, plunger *T* drops into a groove in clutch *F*, thus holding it in the central or neutral position. The knob previously referred to may be set at any part of the stroke to stop the traversing movement at the end of that stroke. The withdrawal of the knob again starts the traversing movement without any further action of the operator. The shaft connecting with bevel gear *R* extends to the front of the machine, and, through suitable gearing, transmits a rectilinear motion to the work-table of the grinding machine. The load-and-fire reverse mechanism is of especial value on grinding machines having a traversing movement.

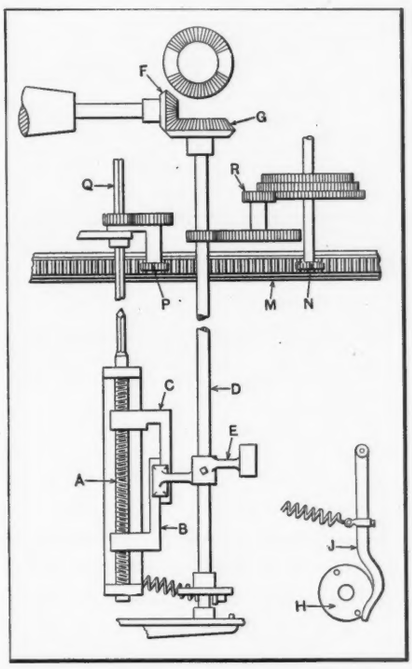


Fig. 9. Mechanism for varying Point of Reversal and Speed of Rotation

"Pattern Chain" for Variable Clutch Control

When clutches are engaged or disengaged automatically, their action is usually controlled either by cams or some form of revolving carrier having one or more lugs or dogs that engage the clutch-operating lever. The ingenious method of controlling clutches illustrated at *A* in Fig. 10 is applied to a textile machine known as a "twister," which is used for producing fancy yarns. The variations in the yarn are obtained by controlling the action of two sets of delivery rolls. The lower rolls *r* and *s* of each set support the upper rolls *c* and *d*. Splined to the end of roll *r* is a shifting clutch member *e*, which revolves the roll when engaged with the clutch teeth on the hub of gear *f*. A similar clutch and gear combination is located at *g* for driving the lower set of delivery rolls. The upper clutch is connected with lever *q*, pivoted at *h*, and the lower clutch with lever *j*, pivoted at *k*. The action of these clutch levers is governed by a pattern chain *l* suspended on a drum *m*. As this drum revolves, the rollers of the pattern chain come into engagement with the lower ends of the clutch levers, thus shifting the clutches into and out of engagement. By changing the position of the rolls or risers of the pattern chain, the pattern of the yarn may be varied and different fancy effects obtained. The chain drum is revolved by means of change-gearing for varying the speed according to requirements. The clutch gears are rotated continuously, and the delivery rolls are only stopped when a knot is being formed, both sets of rolls being rotated while the yarns are being twisted together between the knots.

Another application of an endless chain for controlling the engagement and disengagement of a clutch at predetermined intervals is illustrated at *B*, Fig. 10. This mechanism is applied to a loom. The vertical shaft *a* is driven through bevel gearing (not shown) at the lower end, from the driving shaft of the loom. The upper end of shaft *a* carries a clutch member *b*, which is engaged by the shifting clutch member *c* splined to shaft *d*. Shaft *d*, through the bevel and spur gearing shown, is connected with the chain drum or cylinder *e* carrying the clutch controlling chain *f*. Above this chain there is a lever *g*, pivoted at *h* and connected by link *i* with another lever *j*, pivoted at *k*. The pin *l* connecting the link and lever engages a slot in bellcrank *m*, the movements of which are controlled by a spring *n* and a connector *o*, which extends to another part of the machine. The vertical slot in lever *m* has a short horizontal section at the upper end.

The action of the mechanism is as follows: When the clutch members are engaged, the chain drum and chain revolve, and when one of the links *p* engages lever *g*, the lower lever *j* is raised, thus locating pin *q* in the upper part of the annular groove of the shifting clutch member. As soon as pin *l* at the end of lever *j* reaches the upper end of the vertical slot, the bellcrank lever *m* swings over under the action of spring *n*, thus engaging pin *l* with the horizontal part of the slot and locking the lever *j* in the upper position. As soon as the lever *j* is raised, a projection engages pin *q* and disconnects the clutch, thus stopping the rotation of shaft *d*. The link *p* on the pattern chain is no longer under the roller of lever *g*, but this lever is still held in the upper position by the engagement of pin *l* with the horizontal slot in bellcrank lever *m*. The clutch remains disengaged until the connector *o* swings the vertical part of lever *m* to the right, allowing upper clutch member *c* to engage the lower part again. The movements of the connector are controlled by another chain, which operates on the same general principle as the one referred to.

Full-stroke Mechanism to Insure Completion of a Movement

Mechanisms are sometimes so arranged that hand-operated movements are, to some extent, controlled mechanically, to prevent motion in the wrong direction or incomplete action. The full-stroke ratchet mechanism shown in Fig. 12 is used on the Ellis adding typewriter to prevent the operator

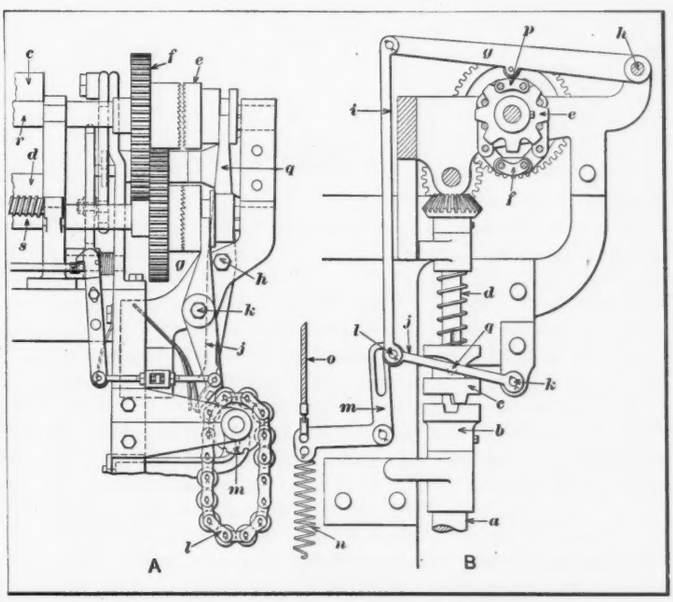


Fig. 10. Mechanisms equipped with Endless Chains for controlling Engagement and Disengagement of Clutches

from starting handle *A* and not completing the required movement. For instance, if handle *A* is in the upper position, as shown at the left, any downward movement must be continued until the handle has made a complete stroke before it can be reversed for returning it to the original or upper position. Similarly, if the lever is at the lower end of its stroke, as shown by the view to the right, any upward movement must be completed before the direction of motion can be reversed. This positive control of the action of handle *A* is obtained in a very simple manner. As the handle is moved downward or upward, pawl *B* is carried with it. This pawl is pivoted to part *D* and normally held in a vertical position by a spring. When handle *A* is at the upper end of its stroke, as shown at the left, and a downward movement is started, pawl *B* engages sector *C* and its upper end swings to the right; as the downward movement of handle *A* continues, pawl *B* engages successive notches in sector *C*, and locks into one of these notches if an attempt is made to return handle *A* before the downward stroke is completed. When handle *A* has been pushed all the way down (as shown to the right), pawl *B* drops into the enlarged notch *E* of sector *C*, where there is enough room to permit the pawl to swing around to the vertical position; consequently, as soon as handle *A* is moved upward, the top of pawl *B* swings to the left and again engages successive notches in sector *C*, thus preventing any return of handle *A* to the lower position until the pawl has cleared the upper end of the sector and again swings to a vertical position.

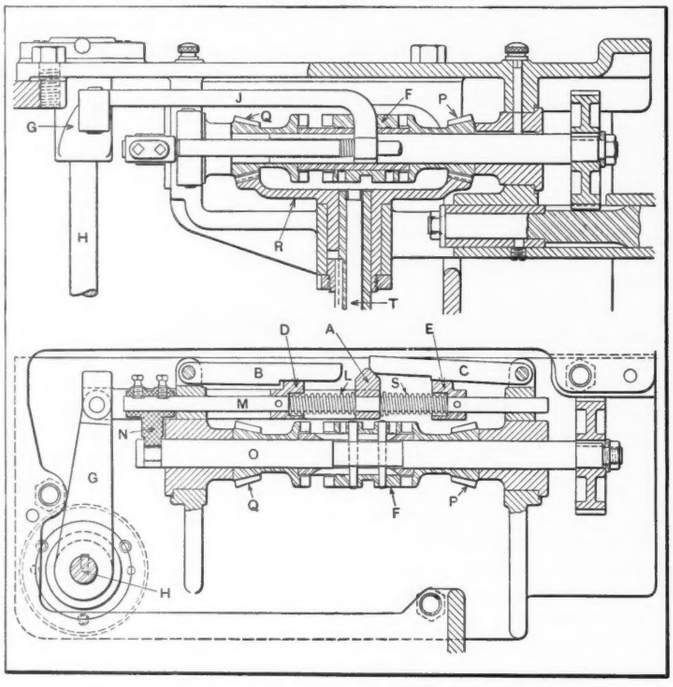


Fig. 11. Spring and Latch Type of Reversing Clutch Control

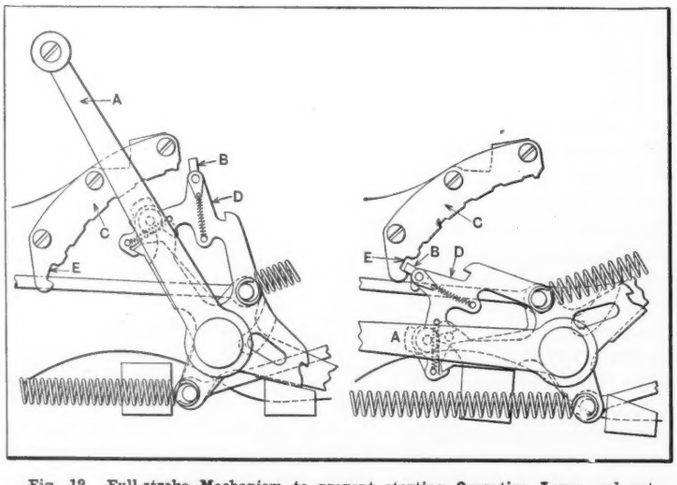


Fig. 12. Full-stroke Mechanism to prevent starting Operating Lever and not completing its Movement

Two-speed Intermittent Rotary Motion

The fast and slow motion of the pattern cylinder of a certain type of loom is derived from the reversible intermittent gearing shown in Fig. 13. The large gear *A* is mounted on the pattern cylinder shaft, and receives its motion either through the segment gear and crank combination *B* or through a similar combination *C*, these two combinations being used to reverse the direction of rotation. Gear *D* is the driver for this train of mechanism. Whether the motion is transmitted from gear *D* to the pattern gear *A* through the crank and segment gear combination *B* or through combination *C* depends upon the position of a sliding key *F*. An intermittent fast and slow motion is obtained with either combination. When key *F* locks the crank and gear *B* to the shaft, the pattern gear is rotated at a relatively slow speed when the segment pinion is acting as the driver, and at a faster speed when the crankpin *E* comes around into engagement with one of the radial slots in the pattern gear. When this direct drive is employed, the gears *G* and *H* revolve idly with the upper crank and gear combination *C*. When a reversal of motion is required, sliding key *F* is pushed in to engage gear *H*, which then drives gear *G* and the combination at *C*.

Intermittent Movement Derived from Crank and Cam Combination

The interesting form of mechanism illustrated in Fig. 14 is used on moving picture cameras and also for feeding films through printing machines. It is commonly referred to as a "claw" mechanism or movement. The claw or hook *A* is double and engages evenly spaced perforations along each edge of the film. When this device is applied to a moving picture camera, the film is drawn, from a roll in the film box, down in front of the lens and then passes to a reel in the receiving box. The film remains stationary during each exposure and is drawn downward between successive exposures, which are made at the rate of sixteen a second. The hook *A*, which engages the film and moves it along intermittently and with much rapidity, receives its motion from a crank and cam combination. The two gears *B* and *C* revolve in opposite directions. Gear *B* has a crankpin upon which the hook is pivoted. An extension of this hook has a curved cam slot that engages a pin on gear *C*. As the two gears revolve, the hook is given a movement corresponding approximately to the D-shaped path indicated by the dotted lines. While this mechanism is shown in a horizontal position, it is normally vertical, with the hook uppermost, when in operation. Some of the other claw mechanisms in use differ from the one shown in regard to the arrangement of the operating crank and the cam or curved slot for modifying the crank motion. For instance, the cam, in some cases, is a separate part that is placed between the crank and the film hook, a pin on the hook lever engaging the cam slot. Another type of claw mechanism derives the downward motion for moving the film and the in and out motion of the film hook from separate cam surfaces.

Rapid Intermittent Motion of Moving Picture Projector

A very rapid intermittent motion is required on moving picture projectors. The film is not moved continuously, but each view or positive on it is drawn down to the projecting position while the shutter is closed, and the film remains stationary for a fractional part of a second while the picture is exposed on the screen; then, while the shutter is again closed, the next successive view is moved to the projecting position. It is apparent, therefore, that moving pictures are, in reality, a series of stationary pictures thrown upon the screen in such rapid succession that they are, in effect, blended together, and any action or movement appears continuous. It is important to give the film a very rapid intermittent motion, because it is

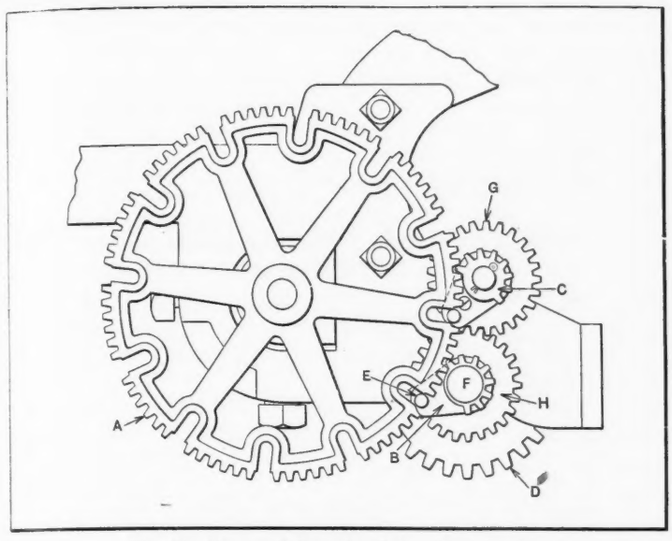


Fig. 13. Two-speed Reversing Intermittent Gearing

necessary to have the shutter closed when this movement occurs; and the length of time that the shutter is closed should be reduced to a minimum. This shutter is in the form of a wheel or disk, and it has a fan-shaped section which passes the projector lens while the film is being shifted. In order to avoid flicker on the screen, the shutter has two additional fan-shaped sections. With these three equally spaced sections, the light is not only shut off from the screen during each successive film movement, but it is also shut off twice between each movement at uniform intervals. By closing the shutter twice while the picture is on the screen, the flicker that would be visible and annoying if the shutter were only closed while moving the film is multiplied to such an extent that it becomes almost continuous and is practically eliminated as far as the observer is concerned, assuming that the projector is operated at the proper speed. The width and area of that section of the shutter which is passing the lens when the film is being moved is governed by the time required for the film movement. Theoretically, the area of each section or segment of the shutter should be equal, although, in practice, the two extra sections are made of somewhat smaller area than the main one, in order to increase the open space and the percentage of area left for the passage of light.

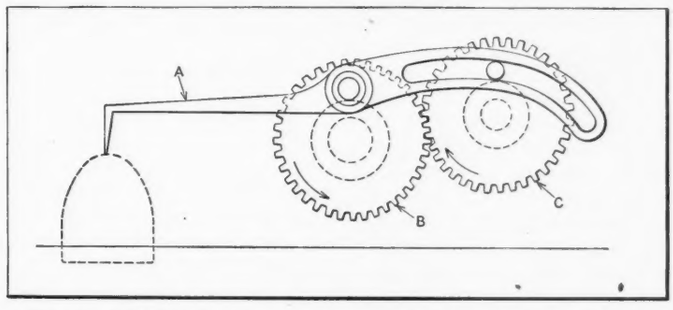


Fig. 14. Crank and Cam Combination for operating Claw Mechanism of Moving Picture Camera

There is an important relation between this shutter wheel and the intermittent motion or gearing of the projector. This is due to the fact that the shutter must be closed while the film is being shifted. With the mechanism to be described, the film movement is very rapid, so that the shutter blades may be proportionately reduced in area, leaving more open space for the light. The intermittent motion referred to is shown in Fig. 15 and is used on the Power moving picture projector. This mechanism is composed of a disk or wheel *A*, having an annular flange or ring *B*, which has two diagonal slots across it as shown; this wheel, which is the driver, imparts an intermittent motion to the follower *H*, which carries four equally spaced pins or rollers that engage the ring *B* on wheel *A*. Each time this wheel makes one revolution, the follower *H* is turned one-quarter revolution and in the same direction, as indicated by the arrows. The follower is stationary except when it is engaged by the slots or cam surfaces formed on one side of ring *B*. During this stationary period, the ring *B* simply passes between the four pins on the follower, two of these pins being on the outside and two on the inside of the ring.

The quarter-turn movement is obtained in the following manner: When the projection or cam surface *G* on the revolving wheel *A* strikes one of the pins, the rotation of the follower begins, and the pins are so spaced that one on the outside moves through a diagonal slot in ring *B* while a pin on the inside moves outward through the other slot. For instance, if the pins *C* and *D* are on the outside and *E* and *F* on the inside, pin *D* will first be engaged by cam surface *G* and, as the follower revolves, pin *C* will pass in through one diagonal slot while pin *E* is moving to the outside of the ring through the other slot. At the completion of the quarter-turn movement, pins *C* and *F* will be on the inside and *D* and *E* on the outside. As wheel *A* continues to revolve, ring *B* simply passes between these closely fitting pins, which lock the follower against movement until projection *G* again comes around and strikes the next successive pin on the follower.

The follower operates a toothed wheel or sprocket which connects with the film and moves it downward each time the shutter is closed. Above and below the intermittent gearing there are other sprockets which rotate continuously, and these are so timed that a loop of film is formed above the intermittent gearing that is just large enough to provide for one film movement, which is equivalent to the length of one view or positive. As the film is drawn down rapidly by the intermittent mechanism, a loop is formed below it which is taken up by the lower sprocket as the film is wound upon the lower receiving reel. The normal speed of wheel *A* is sixteen revolutions per second, and it has been operated at two or three times the normal speed. The time required for turning the follower one-quarter revolution is approximately one-sixth of the time for a complete revolution, or 1/96 second, when running at normal speed. With the well-known Geneva wheel, which has been applied to many projectors, approximately one-quarter of the time is required for the intermittent action; therefore, the shutter blades must be of larger area than when the film movement occurs in one-sixth of the time. However, with the mechanism shown in Fig. 15 there is less tendency to subject the film to injurious stresses. The locking of the follower during the stationary period is also more secure, especially at the critical time when near the operating point. The three holes in ring *B* are to compensate for the slots on the opposite side and to balance wheel *A*.

The concluding installment of this article will deal with mechanisms for the conversion of rotary and rectilinear motions and devices for automatically disengaging a driven member whenever resistance to motion increases excessively.

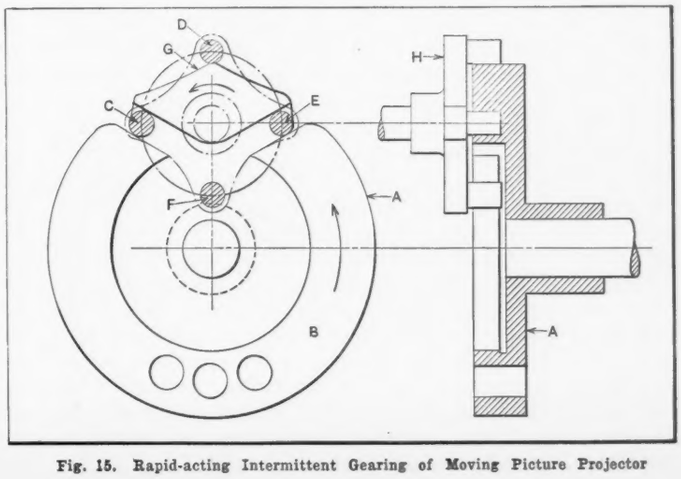


Fig. 15. Rapid-acting Intermittent Gearing of Moving Picture Projector

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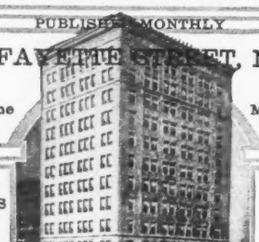

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SALVAGING OF TOOLS

There is not enough steel in the world today to go around. Anything tending to economize steel is a measure of vital importance. The salvaging of tools—making new tools from old—saves steel. It has developed into quite a business; it should be developed further. The subject, which is of national importance, is covered comprehensively in the leading article in this number of MACHINERY. Salvaging of tools is not only valuable because of the individual economies that it may effect; it is valuable, above all, because it prevents the waste of badly needed materials on an enormous scale throughout the country.

Primarily, of course, saving of material by the salvaging of tools is a war measure; but it also has been found profitable in itself by those who have adopted it in their factories. Hence, its survival after the war is over is assured—which proves once more that, terrible as war is, it has made us realize how wasteful we are as a nation; but now that we have learned our lesson at awful cost it will be of inestimable value to us when peace reigns anew over our land.

* * *

THE LABOR PROBLEM

How should the labor problem be handled? Ask any employer. Ask any employe. The chances are that each will have an opinion different from that of any other employer or employe. The only way to get at the consensus of opinion is by a thorough investigation of the whole problem both from the employers' and the employes' point of view. Such an investigation has been carried out by the President's Mediation Commission. It has reported that the main causes of labor difficulties in the United States are: refusal of many employers to deal with the men collectively; absence of disinterested agencies to which resort may be had for peaceful settlement of labor disputes; ignorance of both capital and labor regarding their respective needs; grievances as to hours and wages that create a permanent attitude of ill-will and misunderstanding. To remedy these evils the committee recommended the following: collective bargaining; machinery for settling disputes; the eight-hour day; unified administration of governmental labor agencies; abandonment of output restrictions; elimination of profiteering.

The question of labor is the most important problem confronting the management of present-day industrial undertakings. You cannot side-step it. You cannot solve it by outworn ideas. Be you employer or employe, you must meet it with an open mind and a willingness to recognize fundamental factors. If the problem is tackled in such a spirit there is no reason why it should not be settled without labor disturbances and to the mutual advantage of employer and employe.

* * *

THE MACHINE TOOL INDUSTRY AFTER THE WAR

There is no good ground for pessimism about the machine tool industry after the war. The indications are that peace will bring a heavy demand for machine tools, especially in the four following directions:

The railroads, the equipment of which has dropped below par, must necessarily get it back into first-class condition. The building of ships is not going to stop with the war. On the contrary, not for many years will the world's merchant marine be built up sufficiently to meet the requirements of the world's trade. The motor truck industry has come into its own during these stormy years. Its development when peace returns bids fair to surpass even the extraordinary development of the passenger automobile trade ten years ago. We shall have an airplane industry after the war. The airplane when used under normal conditions is a safe, reliable means of conveyance and it is probable that it will be put to various uses; for instance, as a mail-carrier.

There, then, are four industries in which the demand for machine tools will be great when the war is over. These and other great national activities, to which the war has lent impetus, have in store for them a long period of continued activity in the coming years of peace.

* * *

DIFFICULTY IN OBTAINING PIG IRON

Manufacturers are finding it increasingly difficult to obtain pig iron for use in their foundries. Some blast furnace operators, seeking to protect themselves, request manufacturers to state where their castings are to be used, before supplying the raw material. It is not always possible for a manufacturer to state that the castings which he expects to make are for immediate use in the manufacture of war material, although the product of most manufacturers of machine tools and attachments just now will ultimately be used by the Government, even if the latter has not ordered it at the moment when the castings are made.

The Government, it would seem, might introduce some method for the distribution of iron and coke to the blast furnaces that would permit furnace operators to sell pig iron to manufacturers without requiring the latter actually to show an order from the Government for the material which they intend to manufacture. If every manufacturer must wait for a Government order before he can buy pig iron for making his castings, serious delays will result. If nobody makes any machine tools, chucks, pumps, etc., for stock, nothing will be provided ahead of the immediate needs of the Ordnance Department, so that, when the Government wants to equip a factory for making some specified ordnance material, months will drag along before even the necessary machine tools can be obtained.

The Government's theory seems to be that everyone who is selling goods to the United States has a big contract on hand, requiring months to complete, the exact tonnage for which can be figured in advance. Many manufacturers of machine tools know, however, that small orders from the Government have been the rule rather than the exception. When it is possible to fill such orders from stock, everybody is benefited and the Government obtains its war materials more rapidly.

If a manufacturer is engaged in the making of essential articles, such as machine tools, attachments or other devices used in manufacturing war materials, he should be permitted to obtain pig iron irrespective of whether or not his product, at the particular time when he places his order for the raw material, is actually contracted for by the Government. Restrictions in the supplying of pig iron like those outlined above seriously hamper the conduct of the war.

PLANNING FOR WAR WORK

MAKING ESTIMATES FOR MANUFACTURING FOR THE GOVERNMENT AND EQUIPPING A FACTORY FOR WAR WORK

BY ALFRED SPANGENBERG[1]

A manufacturer who wants to undertake the making of war materials or other supplies for the Government may either be in the position of having a factory that can be turned into a war establishment already equipped for the period of the war, or he may have facilities for building and equipping a new factory to undertake such work. In case he has a factory already equipped, it is, of course, important that he select the right kind of work for the machine tool equipment on hand. Even if he is to equip a new factory, it is the best plan to select some class of work that can be made with general-purpose machine tools, as then, when the war contract is completed, the equipment may be used for the manufacture of some other line. In general, therefore, it may be said that when possible a contract that can be completed mainly by an equipment of lathes, milling machines, grinders, planers, boring mills, drilling machines, and gear-cutters is of the greatest advantage. The bid can be made lower because the machine tools can be diverted into other uses after the completion of the work. The contract can be completed more rapidly, as special machinery need not be ordered, and on the whole both the Government and the manufacturer are best served by the selection of such a contract as the present equipment is best fitted to handle.

Factors to Consider in Estimating on a Contract

Having determined upon the class of work best fitted for the organization and equipment already on hand or most easily obtainable, the next thing is to secure from the Ordnance Department at Washington complete blueprints and specifications of the work to be done. As soon as the amount of material needed for a given contract has been determined, it is necessary to secure immediately from the sources of supply information concerning prices and deliveries of the materials required and of the additional machine tool equipment necessary. The size of the contract to be undertaken, that is, the number of parts or units for which the manufacturer should bid, is determined by several factors: (1) By the available buildings, if no further additions are desirable; (2) by the available equipment and the dates of delivery of new equipment to be bought; (3) by the available and possible labor supply; (4) by the available working capital, which, of course, determines several of the factors above; (5) by the dates of delivery of the material, devices, or machines to be made for the Government.

Quite frequently, the most desirable work suitable for the organization or machine tool equipment cannot be selected for bidding, because it is impossible to secure early enough deliveries of the additional machine tool equipment needed.

Estimating Cost of Work

In order to determine the cost of the work as a basis for the bid and also the number or sizes of machine tools required, each part to be made must be considered separately with regard to the various machining operations. The time required for every operation must be estimated. If this time estimate is carefully made and recorded it will prove of considerable value in setting the piece rates. Having made the time estimate, it will be possible to determine how many machines of each type and size are required, how much the overhead cost will be, and, in consequence, the total cost of the work, so that the proper bid can be made. In obtaining the time estimates it has been found that the machine tool builders are generally willing to cooperate by suggesting designs of special equipment for their machines and giving the approximate time in which operations can be done with such attachments.

Selecting Machine Tool Equipment

The war will not last forever, and for that reason the machine tool equipment, if it has to be bought for the work, should be selected with this idea in view. Mainly, general-purpose machine tools should be installed instead of special machines, so that the factory can be used for commercial work after the war. In doing so, a few of the guiding principles would be as follows: Instead of putting in a number of machines of one size, although all the work could be done on that size, it is an advantage to consider future requirements and to put in a variety of sizes. As an example, assume that eight No. 2 milling machines would be satisfactory for the work in hand. A more balanced equipment for future use would be provided, however, if the equipment selected included four No. 2 machines, two No. 3 machines, and two No. 4 machines. This, of course, would not be quite as economical on the present contract as would eight machines of the smaller size, but in most instances the more balanced equipment would prove more useful in the manufacturing to be undertaken after the war.

Machines that are suited to a number of different operations are preferable to those that can be used for one or a few operations only, although some of these different operations may not be required for the contract in hand. While single-purpose machines may be more economical for the present work, the guiding principle is an unknown future factor, and as in many instances it is not possible at this time to determine what work the shop will eventually do when peace comes, it is better to provide for a wide variety of operations.

Even though it may cause some delay in delivery, it is worth while to try to obtain machines from one manufacturer, as it is then possible to use the attachments and other auxiliary equipment on the interchangeable plan. This is quite an important factor in equipping any factory. Heavy machines are advantageous, even though the present contract could be done satisfactorily on lighter machines, because it is likely that in the future machine tools will be required to stand up under cuts that are as heavy as stellite or high-speed steel tools will permit, and for this reason the heavier the machine the better. Motor-driven machines are in many instances an advantage, but at the present time they can only be obtained at a sacrifice in time of delivery, on account of the difficulty of obtaining electrical equipment.

While some of the work to be made may be quite special in its nature, attachments for standard machine tools will generally make it possible to carry out the operations satisfactorily when the contract is not large enough to warrant the purchasing or the designing and making of special machinery. For example, a circular arc can be milled on a plain milling machine by a special attachment. Less expensive machine tools can also often be utilized to advantage for special operations. A lathe, for example, can be temporarily utilized as a horizontal boring machine by providing means for guiding boring-bars. Automatic machines may not be warranted on account of the comparatively small number of parts to be made, and while it will take more time to make these parts on a standard machine tool, it may sometimes be advisable to do so, as the investment in the automatic machine might greatly increase the cost of the parts. As a rule, there are many small parts which can be more advantageously sublet than made in the shop, such as small screws, bolts, studs, and nuts. It is often also an advantage to have a firm specializing in graduating do such work, if the contract requires graduations to be made. While waiting for the material to be delivered, jigs and fixtures for the contract are designed and the machine tool equipment may be kept employed on the fixture work.

Arrangement of Machines

The grouping of the machine tools will be found most effective for general requirements if done according to the kind of machine or class of operation to be performed. Of course, in the making of shells, fuses, or similar war work, where thousands of interchangeable parts are passed through the shop daily, grouping according to kinds of machines would not be advisable, as in the latter case the grouping should be such that the material may pass in one continuous flow through the shop. When a comparatively small number of complete machines or devices are to be made, however, grouping according to class of machine tool has several advantages, one of which is that it permits group drive from a short lineshaft driven by an electric motor. In this way, the lineshaft for the same class of machines may be driven at the most suitable speed for this type of tools.

[1]Superintendent, Ordnance Department, Mead-Morrison Mfg. Co., East Boston, Mass.

Tool Equipment and Jigs

The tool-room is the heart of the shop, and should be well equipped. Interchangeable manufacture, the fundamental principle of economical production, can only be secured by making jigs and fixtures that are accurate. Hence, the tool-room equipment should include the necessary outfit of surface plates, test indicators, vernier height gages, parallels, block gages for obtaining accurate measurements, and checking up gages for maintaining the required standard of accuracy. In purchasing the tools the same principles should be applied as in the selection of the machine tool equipment. Tools of general application should be used in preference to special tools when possible, and those of the same class should preferably be purchased from one manufacturer. It is well to have the tool equipment complete and a full line of standard sizes of reamers, drills, counterbores, and taps greatly facilitates the work in the shop, the making of jigs and fixtures, and the repairs on the machine tool equipment. Time is saved in not having to wait for sizes not on hand, and an ample supply of high-speed milling cutters, including plain, side, and end mills is required, as well as an ample supply of lathe and planer tools of standard shapes. Each lathe, planer, and shaper should have its own complete equipment of these tools, with several sets of duplicate tools kept ground to the proper shape in the tool-room. The practice of having the workmen grind their own tools should be discouraged.

While the advantage of having fixed gages cannot be denied, work of the nature referred to in the preceding paragraphs can be more economically done by using adjustable limit gages, because these may be utilized for future work when the present contract is completed.

* * *

STANDARD METHODS FOR DIMENSIONING DRAWINGS

The engineering departments of large manufacturing concerns have come to realize the necessity of adopting standard methods of dimensioning drawings. This necessity arises from the frequent mistakes made in reading dimensions on drawings when the draftsman is allowed to use any method that he prefers. It is only natural where many draftsmen are employed that widely different methods will be used that confuse the foremen and machinists to whom the drawings are given. To avoid these mistakes, the engineering department of a large concern manufacturing war munitions, furnishes each member of the engineering department with a copy of a data sheet giving the following directions:

All dimensions of 48 inches and under are to be shown in inches; dimensions over 48 inches are to be shown in feet and inches.

The inch sign is not to be used upon gage drawings or upon tool equipment drawings, when the sizes are below 48 inches.

Upon drawings for buildings, floor plans, etc., the foot and inch signs will be used, but will invariably be given the reverse slant, in order to avoid confusion with the minute and second signs of subdivisions of the circle.

The decimal subdivisions of the inch will be used invariably upon all drawings of machine and tool equipment; but the fractional subdivisions of the inch will be used upon drawings of buildings, floor plans, etc.; also in notes calling for standard taps, reamers, bolts, etc. Decimal points should be made heavy.

When a dimension is not to scale, it is to be underscored with a heavy black line.

If more than two views of a piece are shown, the distances between the projected views are to be equal, care being taken that views are neither crowded nor too far apart.

Unimportant dimensions, if any, should be left blank, so that workmen will know where to work close.

Over-all dimensions should always be given.

Arrow heads should be made free-hand and about 60 degrees between wings.

Limits of Variation from Exact Dimensions

As it is impractical to work to the exact dimensions given on the drawings, the limits of variation permissible will be indicated by the number of decimal places used, upon the following basis:

Figures carried to one decimal place indicate that the total limit is 0.1 or ± 0.05. Figures carried to two decimal places indicate that the total limit is 0.01 or ± 0.005. Figures carried to three decimal places indicate that the total limit is 0.001 or ± 0.0005. Figures carried to four decimal places indicate that the total limit is 0.0001 or ± 0.00005.

When a dimension is followed by the plus sign (+), it indicates that any variation from the given dimension must be over size within the total limit.

When a dimension is followed by the minus sign (—), it indicates that any variation from the given dimension must be under size within the total limit.

When a dimension is followed by an "approximation sign" (ap), it is to be understood that any reasonable limit of variation will be permitted.

When the variation permissible is different from that given above, the dimension is to be followed by the plus and minus sign ($\pm$), the plus sign (+), or the minus sign (—), and the amount of limit, thus:

1.2 ± 1 indicates that total limit is 0.2 or, plus or minus 0.1.

1.82 ± 2 indicates that the total limit is 0.04 or, plus or minus 0.02.

1.258 ± 5 indicates that the total limit is 0.010 or, plus or minus 0.005.

1.0937 ± 3 indicates that the total limit is 0.0006 or, plus or minus 0.0003.

1.1875 ± 20 indicates that the total limit is 0.004 or, plus or minus 0.002.

$1.3906 + 30$ indicates that the dimension must not be under size, but may be 0.003 over size.

$0.1285 - 20$ indicates that the dimension must not be over size, but may be 0.002 under size.

$0.281 \begin{smallmatrix} +2 \\ -1 \end{smallmatrix}$ indicates that the total limit is 0.003 and that the dimension may be 0.002 over or 0.001 under size. A.

* * *

AN INDICATOR USED FOR CUTTING INTERNAL THREADS

BY ALFRED E. CARTER[1]

On old lathes there are often found deep file marks on the bed, which were used to indicate the stopping place while cutting internal threads. This was done by many early mechanics in order to tell when the bottom of a hole was reached, and also to avoid breaking the tool. When there is a squared bottom or shoulder in a threaded hole, it is customary to recess to the depth of the thread in order to clear the point of the tool, but whether this is done or not, the following is a positive way of telling when the tool has reached the same place every time, and without breaking the tool in doing so:

Run the tool in the hole to the correct depth with the lead-screw engaged before beginning to cut. Then mark the lathe bed, with chalk, as close to the carriage as possible; fasten a heavy wire to the lathe bed by means of a clamp, or by placing it under one of the screws of the headstock, so that it points across the side of the jaw chuck in line with the operator's eyes. Next, mark the side of the chuck opposite the end of the wire and proceed to cut the thread as usual. It is apparent that if the operator will carefully watch the mark on the bed, until the carriage is approximately the width of one thread short of the full distance, the mark on the chuck will also be seen just passing under the pointer. The operator should next watch for the mark on the chuck coming over again, and as it reaches the pointer, which is exactly as first set, disengage the tool and reverse the lathe, thus avoiding all possibilities of destroying the tool and the work.

Owing to the large outside diameter of the chuck, the mark would have to be some distance either side of the pointer to make an appreciable variation in the tool travel. This method is more accurate than if the tool were visible to the operator. If there is a large recess, it is possible to do without the pointer, as there is little difficulty in gaging the position of the mark with the eye.

* * *

It is sometimes necessary to discard precedent and adopt unusual methods in order to facilitate manufacturing processes. An example is to be found in the new method of building and launching concrete boats which is being employed in Norway. It has been found that the boats are cast much more easily when built bottom side up. When this method is employed the boats are launched upside down, and as the air is permitted to escape from the air-tight chambers in the interior, the vessel automatically rights itself.

[1]Address: 164 Slater Ave., Providence, R. I.

MEASURING TEMPLETS AND SCREW THREADS WITH A MICROSCOPIC MEASURING MACHINE[1]

CONSTRUCTION AND ADJUSTMENT OF MEASURING MACHINE AND APPLICATION FOR TESTING ACCURACY OF TEMPLETS OR CONTOUR GAGES AND SCREW THREADS

BY FRANKLIN D. JONES[2]

MICROSCOPIC measuring machines provide a convenient and accurate means of measuring certain forms of templets and gages which, because of their shape, cannot readily be measured by other forms of precision measuring instruments. The microscopic measuring machine referred to in the following is used in conjunction with end measuring gages, and it differs in this respect from the type that depends upon the accuracy of a screw for determining the length measurements. This machine is shown in Fig. 1 with a hob between the centers, as it is, of course, used for testing tools of this kind and plain screw threads, as well as templets or gages, form tools, or any edge or contour, the accuracy of which cannot be tested by ordinary means.

The machine has a rigid box-shaped bed upon which is mounted a table *A*, fitted with centers for holding all tools having centered ends. The center seen at the left has a crosswise adjustment which enables the part being tested to be lined up accurately. When taking length measurements, table *A* is adjusted along the bed whatever distance may be required. This distance is determined by placing standard measuring rods or gage-blocks between hardened contact pieces. One of the contact pieces is attached to the end of table *A* and the other one is fixed to block *B*. The microscope is mounted on a compound slide-rest having movements parallel with, and at right angles to, the table slide. The microscope may be adjusted vertically, of course, for focussing, and it is fitted with two hair-lines. One of these may be rotated with the outside tube, whereas the other one rotates with the eye-piece. The outer tube has a large dial *C*, which is graduated in half degrees. The eye-piece carries a vernier graduated for taking readings to one minute, so that the angle between the two hair-lines may be determined with considerable accuracy.

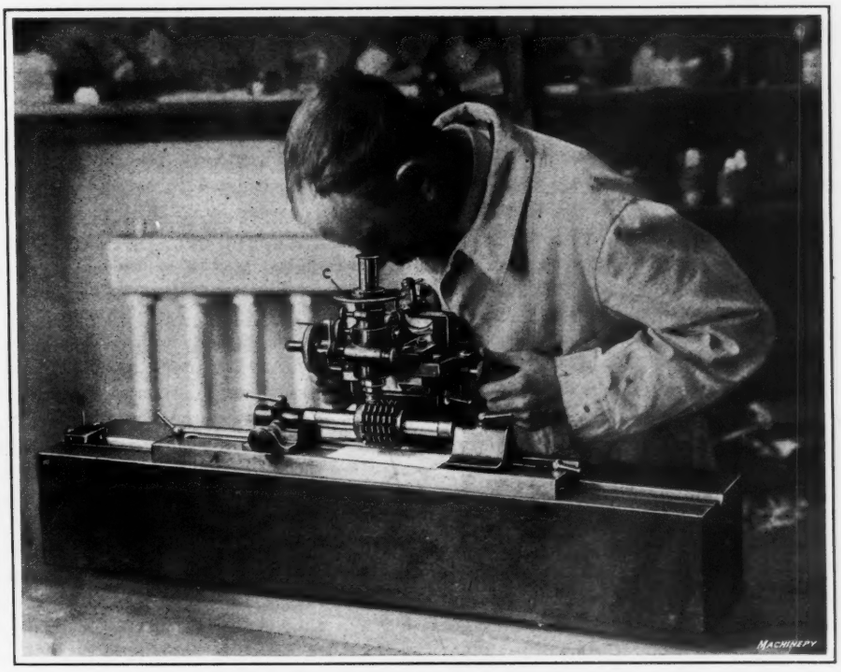


Fig. 1. Microscopic Measuring Machine testing Accuracy of Hob

This machine is shown in Fig. 2 fitted with an apparatus for illuminating whatever edge or contour on the work is under observation. The object of using this apparatus is to obtain a better illumination than is afforded by uncontrolled lighting. The rays of light from an electric bulb are directed onto the surface of a mirror located directly beneath the side or edge of the work under observation. The light rays are reflected upward by the mirror, thus showing the profile of the work in distinct relief when viewed through the microscope. This illuminating attachment is carried by a bracket bolted to the rear side of the bed. The electric bulb is located inside and at the outer end of the tube shown. At the other end of this tube there is a collecting lens, and midway between the bulb and the lens is a metal partition having a small hole through which the light passes and is then diffused by a piece of ground glass fitted over the hole. The light tube can be adjusted in a lengthwise direction for varying the strength of the illumination. The rod which carries the mirror has a rack-and-pinion adjustment for locating the mirror in the correct position relative to the work.

Length Measurements

When making a plain length measurement with this machine, the work is clamped to the table, which, in turn, is clamped to the bed after a measuring rod or one or more gage-blocks has been placed between the two compact pieces. The microscope is then focussed on the end or edge of the part to be measured and is adjusted until the hair-lines coincide with the particular point from which the measurement is to be made. The table is next adjusted a distance equal to the required measurement, by means of other measuring rods or blocks. The position of the hair-line relative to the work then shows whether the distance between the points on the work corresponds to the actual measurement or to the difference between the lengths of the two measuring rods. If there is any variation, the amount of error can be determined readily by adjusting the compound slide of the micrometer until the hair-lines exactly coincide with the second point on the work; the graduated dial of the micrometer slide then indicates the error. As the hair-lines can both be rotated, they can be set to coincide with whatever edge or profile the measurement is to be taken from.

Measurement of Templets

The gage or templet shown in Fig. 3 is an example of the class of work which may easily be measured by this machine. The particular measurements indicated in the illustration, however, would be rather difficult to check with any other form of gage or measuring instrument. This templet is clamped to the table with its long sides parallel to the edges of the table and with one of the angular edges or ends of the recess under the microscope. One hair-line is adjusted to cover the long side of the templet and the other is located at right angles, the intersection coinciding with the outer corner from which the measurement is to be made. (We shall assume that two end-measuring rods are used having a difference in length of 2½ inches.) The table is next moved along the bed and reclamped with the longer measuring rod in position. Since

[1] For additional information on thread testing, see "Projection Method of Testing Screw Threads," April, 1918, and articles there referred to.

[2] Associate Editor of MACHINERY.

this gives a movement of 2½ inches, which is somewhat greater than the distance to be measured on the gage, the compound slide is used to obtain the exact adjustment required. For instance, if the measurement is between the outer corners of the high-limit side of the gage, the compound slide will have to be adjusted an amount equal to 2.5 — 2.422 = 0.078 inch.

The hair-line should first be set to coincide with the work before taking the reading. If the micrometer is first adjusted to the required dimension and an observation is then made to see if the hair-lines coincide directly with the work, slight errors in the reading are more likely to occur. By repeating the adjustments previously referred to, the length of the notch or recess at the bottom can also be determined. The depth of the recessed portion is tested by simply setting one hair-line to cover the outer edge and then adjusting the compound slide until this hair-line coincides with the inner edge, the reading between the two positions being noted.

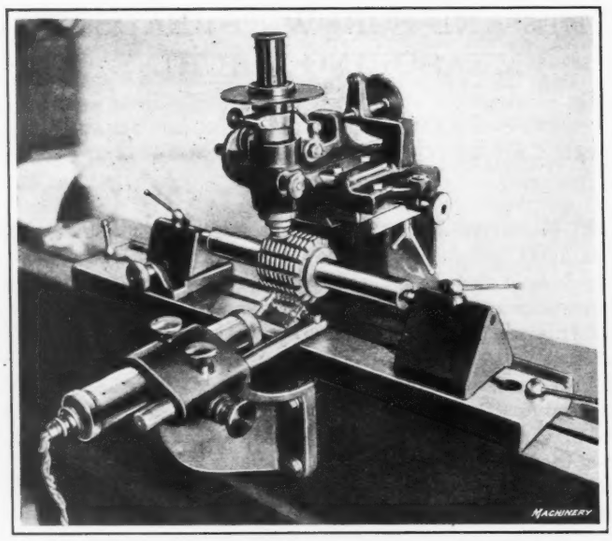


Fig. 2. Microscopic Measuring Machine equipped with Apparatus for illuminating Work

When setting the long sides of the gage or templet parallel to the table, the hair-lines may be used to advantage. One of the hair-lines is set parallel with the table edge, and at the same time the templet is held by hand so that it also coincides with this edge. The table is then moved slowly in an endwise direction, and by adjusting the hair-line and templet with the table movement a parallel setting can be obtained. After the templet is clamped to the table, its position should be tested again.

The form of templet shown in Fig. 4 is another interesting example of the class of work for which the microscopic measuring machine is adapted. In this case, a measurement equivalent to 2.6043 inches is taken near the upper end of the templet. The measurement is taken between two points along the curved sides instead of attempting to measure from one corner of the gage to the other, which is difficult, especially when, as in this case, the corner is formed by the intersection of a curve and a straight line. As the illustration shows, the measurement is taken at points located 5 inches from the base of the templet. It is necessary first to determine this dimension (2.6043 inches) by calculation. The templet is then carefully set with its two straight sides parallel with the edges of the table and with the shorter side under the microscope. The hair-lines are set at right angles to each other, and with one of them covering the edge or short side. The microscope is then moved over 0.190 inch in this particular case, and an ordinary length measurement is taken from one curve to the other by the method previously described for plain length measurements. The width of the base is measured without any calculation, as the tangent to the curve is at right angles to the base line, so that it is easy to set the hair-lines to coincide with these edges. One hair-line is adjusted to coincide with the base or lower edge, and the other one is set at right angles. The length is then measured in the usual way.

Still another example of templet measurement is illustrated in Fig. 5, which shows the master templet for a gear hob forming tool. After this templet is cut out, the angle of the flanks is tested and also the thickness at the pitch line, the width at the top, and the other dimensions indicated.

Measurement of Screw Threads

The microscopic measuring machine may be used for testing the pitch, depth, and angle of screw threads or the teeth of hobs, taps, or chasers. If the threads are finer than six per inch, the pitch and angle can be measured in one operation. The coarser threads require two operations, one side of the thread being used while measuring the pitch. To test the angle of a thread, the microscope is focussed on the thread profile, and one hair-line is rotated until it coincides exactly with one side of the thread; the other hair-line is then adjusted to coincide with the other side of the thread. In order to do this, an adjustment of the compound slide may be necessary. The thread angle is indicated by the reading on the graduated dial *C*, Fig. 1. In order to test the pitch, the table is next moved endwise any whole number of inches up to twelve. After this adjustment, if the hair-lines again coincide exactly with a thread, this indicates that the pitch is accurate, although to detect local errors or those that might exist between adjacent threads or in relatively short lengths of the screw would require repeated observations. The depth of thread is easily determined by superimposing one hair-line on the other and then setting the hair-lines to coincide first with the tops and then with the roots of the thread. The micrometer dial of the compound slide-rest indicates the depth and whatever error there may be.

When measuring a hob or tap, the microscope can be focussed directly on the sharp profile or cutting edge of the tool, but if a plain screw thread is to be tested, the focussing is a little more difficult. A simple method of obtaining the correct focus is to use a small block of steel or other material having two parallel faces lapped to a polish. The distance between these parallel faces should be equal to the height of the work-holding centers of the measuring machine. On one of the faces a fine line should be scratched, and then the microscope can be accurately focussed on this line before placing the work between the centers.

The machine illustrated in Fig. 1 is made by Alfred Herbert, Ltd., Coventry, England. This machine was used at first in the tool-room for the accurate measurement of form tools,

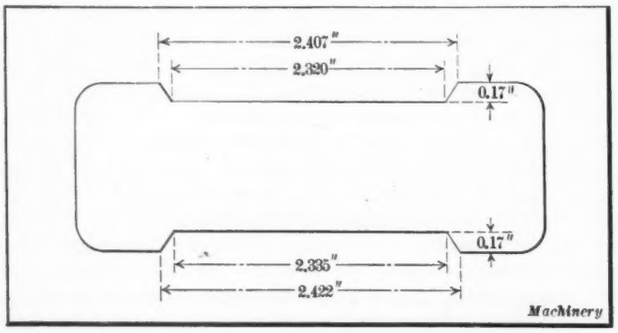


Fig. 3. Gage or Templet measured by Microscopic Measuring Machine

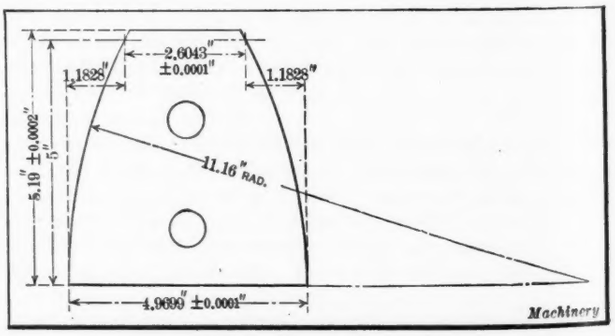


Fig. 4. Another Example of Gage or Templet Measurement

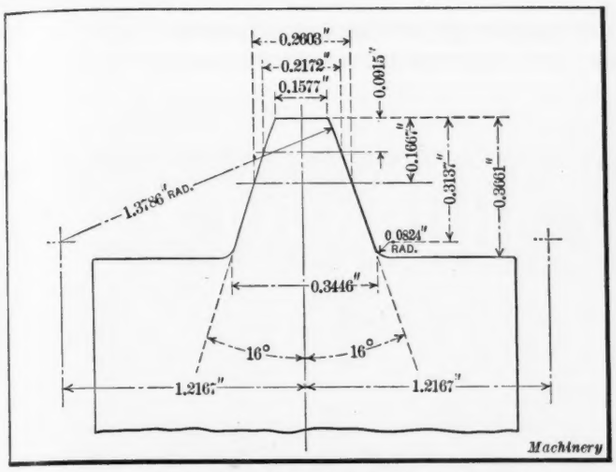


Fig. 5. Master Templet for a Gear Hob Forming Tool

gages, screw threads, etc., and proved to be so valuable for this work that it was placed on the market. The machine will measure lengths up to a maximum of 12 inches, and the microscope has a magnification of 25 diameters.

* * *

ADVANTAGES OF COMPARING MANUFACTURING METHODS

BY D. M. PERRILL[1]

Recently the superintendent of a large shipbuilding concern that has three plants on the Great Lakes found that in one of the shops it took twice as long to perform a certain drilling operation as it did in one of the others. For some time it had been noted that, while the drilling department of one plant was able to keep its work moving under the present demands, the other department was constantly behind. An investigation showed that one shop was using coarser feeds; by adopting the same feeds, the other drilling department was able to increase its production so that no further delays on this account were experienced. A further comparison of the results obtained in all the departments of the three plants resulted in a great saving.

Recently a machine tool company made a comparison of present rates of production with those obtained in previous years and was surprised to learn that in a great many cases these rates had decreased. Changes in foremen, men, and methods had sometimes resulted in lowered production on individual pieces even when general results were greatly improved. By giving special attention to these pieces, the previous results were secured or bettered with a corresponding saving. In another instance, a lathe manufacturer with lathe departments in two adjoining shops found, on comparing methods used in manufacturing similar pieces, that they were often entirely different, sometimes one shop and sometimes the other producing the better results. By using the better method in each instance, a general improvement of the output was secured.

Where a comparison in methods or results can be made, it is very valuable. There is no man with several duties to perform who can resist centering his attention in some one direction, and it is only natural that every foreman should have some pet jobs on which he fixes his attention, to the neglect of other work that should be given equally close study. This work may be the very one on which some other man is working, so that a comparison of the results obtained by each man will be mutually beneficial. Then, too, when the matter is presented to him in the right way, a foreman who finds that he has been overlooking certain jobs will usually try to avoid neglecting others in the future. Often when a man has been doing a thing in one way for years, it becomes almost impossible for him to think of it in any other way; it becomes the only way to him. When this sameness is disturbed in one instance, it is much easier for him to obtain a new viewpoint on all of his work.

[1]Address: 346 Probasco Ave., Cincinnati, Ohio.

Some of the improvements and methods that will be found will simply be a matter of speeds and feeds; others will be results that can be obtained with tools already in stock. If the writer's experience is any criterion, there are few shops engaged in a general line of manufacture that are realizing anywhere nearly full capacity from modern machine tools and tool steels. Where the improvements are obtained simply by changing the feeds or speeds or using tools already in stock, any time saved is clear gain. Any pressure used in securing such results can hardly be other than conducive of greater profits. Where the new methods require special tools, fixtures, or additional machinery, however, the matter becomes one of deciding whether the additional profit justifies the expense, and if it does, whether it is the best way in which the money can be spent.

* * *

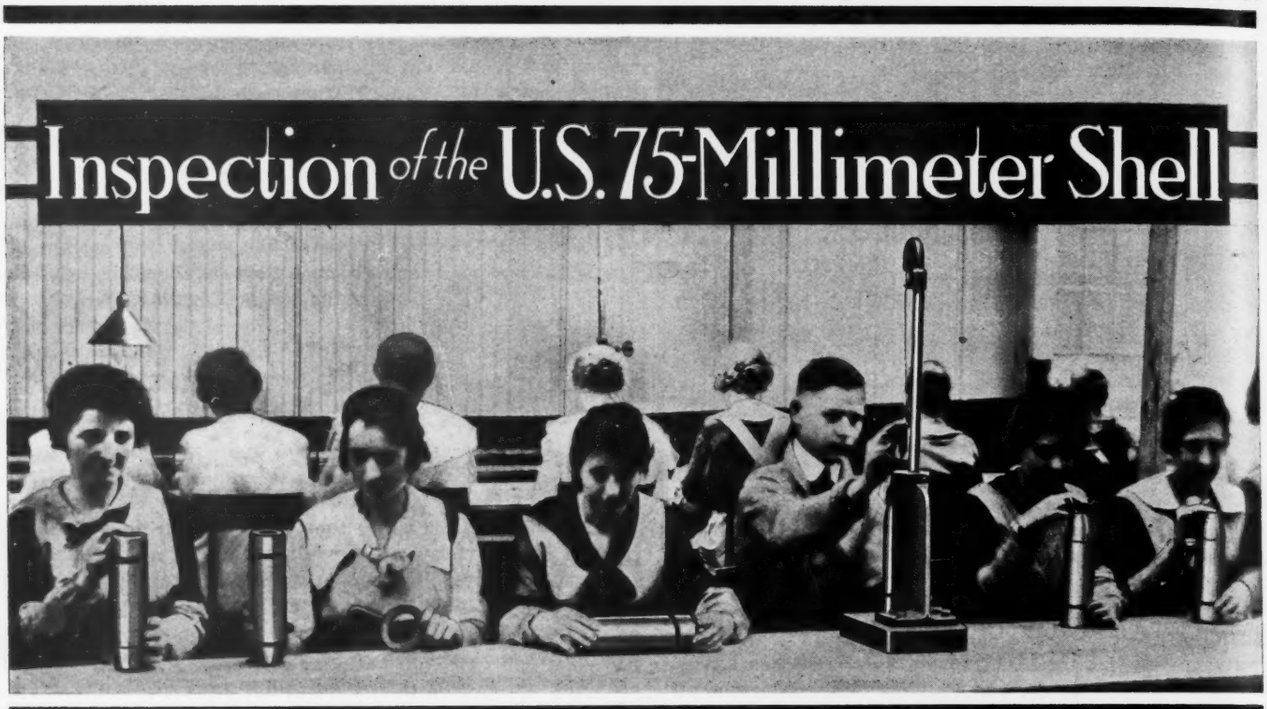
DESIGNING FIXTURES TO INCREASE PRODUCTION ON DRILLING MACHINES

In cases where the time required to set work up on a drilling machine and the drilling time are both considerable, a satisfactory rate of production cannot be expected where one operator devotes his entire time to a single drilling machine, unless special means are provided to keep the operator employed during the time that the drilling operation is being performed. If attention is not paid to this point, the drilling machine is idle during the time required by the operator to set up the work and the operator has nothing to do while the machine is actually performing the drilling operation. Such an unnecessary waste of time by both the machine and the operator can be avoided where work-holding fixtures are so designed that the operator can set up a piece in one section of the fixture while the drilling operation is being performed on a piece held in another section of the fixture; then when the drilling operation has been completed and the drill backed out of the hole, the fixture is adjusted to bring the next piece of work into the drilling position, so that the machine can immediately start upon the next operation. In the accompanying illustration there is shown one of the high-duty drilling machines built by Baker Bros. of Toledo, Ohio, which is equipped with a fixture that enables the machine to be operated on this principle. As shown, the operator has set up a piece *A* ready for the next operation and the drill is being backed out of the finished part *B*. The fixture will next be run over to bring work *A* into the drilling position and while the hole is being drilled in this piece, the operator will remove the finished part *B* from the fixture and substitute a new piece. In this way both the machine and operator are kept busy nearly all of the time and the rate of production is very greatly increased.

E. K. H.

Baker Bros. High-duty Drilling Machine equipped with Double Fixture, so that One Piece can be set up while drilling Another Piece

Inspection of the U.S. 75-Millimeter Shell



Third of a Series of Articles Describing Approved Methods Employed by the American Shell Co. in the Making of U. S. Ammunition — By Erik Oberg[1]

IN the preceding articles in this series, the manufacturing and heat-treating methods in the making of the U. S. 75-millimeter shell by the American Shell Co., Paterson, N. J., have been described; in the present article, the inspection methods and gages will be reviewed, including both the company's inspection and that of the United States Government in accepting the shells. The inspection may be divided into three distinct parts: (1) The inspection that takes place after each operation to prevent defective shells from passing to succeeding operations unless the previous ones have been properly performed. (2) The complete shop inspection of the finished shell in which all dimensions are gaged before the shell passes to the government inspectors. (3) The government inspection which largely duplicates the final shop inspection, but also includes a few additional gaging operations.

Inspection after Various Machining Operations

On page 595 of the March number of MACHINERY, the order of operations in the making of the U. S. 75-millimeter shell was given, together with the order of the various inspections during the process of manufacture. After the forging has been cut off on a power hacksaw, it is inspected for length simply by measuring it roughly by a scale. The first actual shop inspection takes place after the first rough-turning of the entire outside of the shell, for which gage No. 1, Fig. 1, is used. This is a limit snap gage, as indicated. The shells pass from the machines on gravity conveyors to the inspector's table. In addition to inspecting the shell for size, the inspector, who is assisted by a checker, records the number of accepted and rejected shells from each operator. Each shell as it comes to the inspector has the operator's number marked on it in chalk, and as the inspector gages it, he calls off the number to the checker, who records it. The number of accepted shells passing the inspector's table is also recorded by pressing an electric switch once for every shell accepted, the number being thus recorded in the production office by means of a productograph. This office, therefore, has, at all times, an absolute record of the number of shells in operation throughout the shop, and should the production fall off at any one operation,

[1] Editor of MACHINERY.

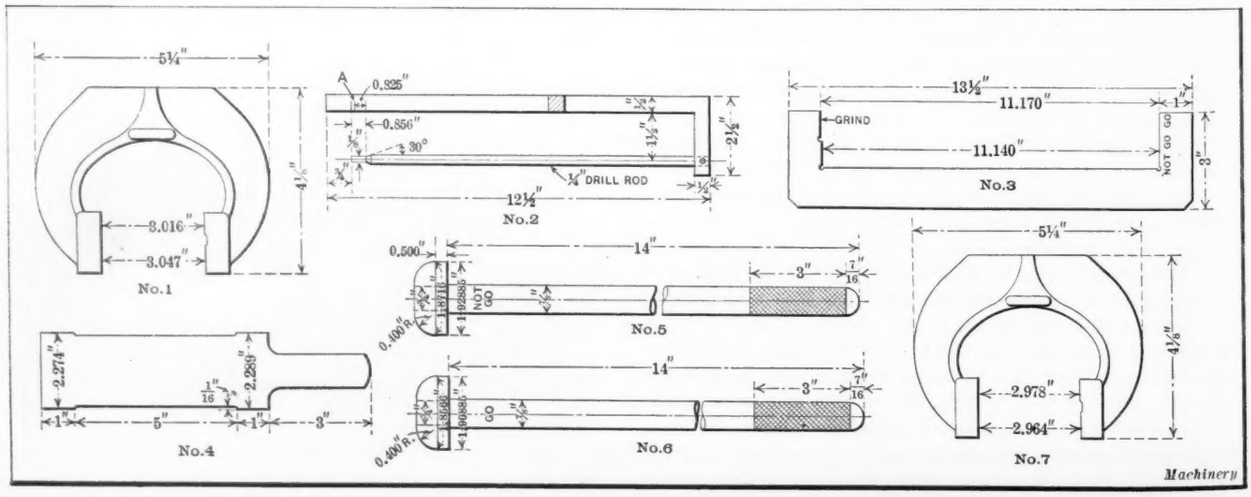


Fig. 1. Gages used in Inspection of U. S. 75-millimeter Shell referred to in Article as Nos. 1 to 7

the cause can be immediately investigated and the difficulty remedied. The checking and recording is repeated at every inspection table.

The next operation is the rough-facing of the base, after which the thickness of the base is inspected by means of gage No. 2. This gage is provided with two lines at *A* indicating the limits of variation permissible for the base thickness. When the stem of the gage is inserted into the shell, the base surface of the shell must come within the distance indicated by the two limit lines. One inspector and one checker are used for this inspection. The inspector stamps on the bottom of the shell the lot or code number of the shell forging which, in the saw shop, was stamped on the face at the open end of the shell, this number being the same as that on the forging when it comes to the shops from the forging plant. The reason for transferring this stamp to the base is that in the next operation the open end will be faced and the number removed.

After having rough-faced the open end, the length of the shell is gaged by the limit snap gage No. 3. One inspector can do both the gaging and the checking off of the number of shells at this operation.

ferred at this point from the end of the shell to the side, two stampers being employed on this work.

First Government Inspection

As the shell is now ready for the heat-treatment, it is subjected to a government inspection at this point. This inspection consists of a visual inspection of the inside and outside of the shells to see that they are not too rough, comparison of the stamps on the side and the bottom of the shell to see that the lot number has been properly transferred, and gaging of the taper of the bore, the diameter of the bore above the taper, and the cavity of the bore at the base. Gage No. 8, Fig. 2, is used for testing the taper, this gage being made from flat stock 3/16 inch thick. A gage similar to No. 4 is used for testing the diameter above the taper, and gages Nos. 5 and 6 are used for gaging the cavity of the bore at the base, the repetition of the inspections previously made by the company providing a double check to insure that no shells are heat-treated that are not of correct dimensions. The government inspector stamps the shell with the government inspection stamp and passes it to the nosing presses.

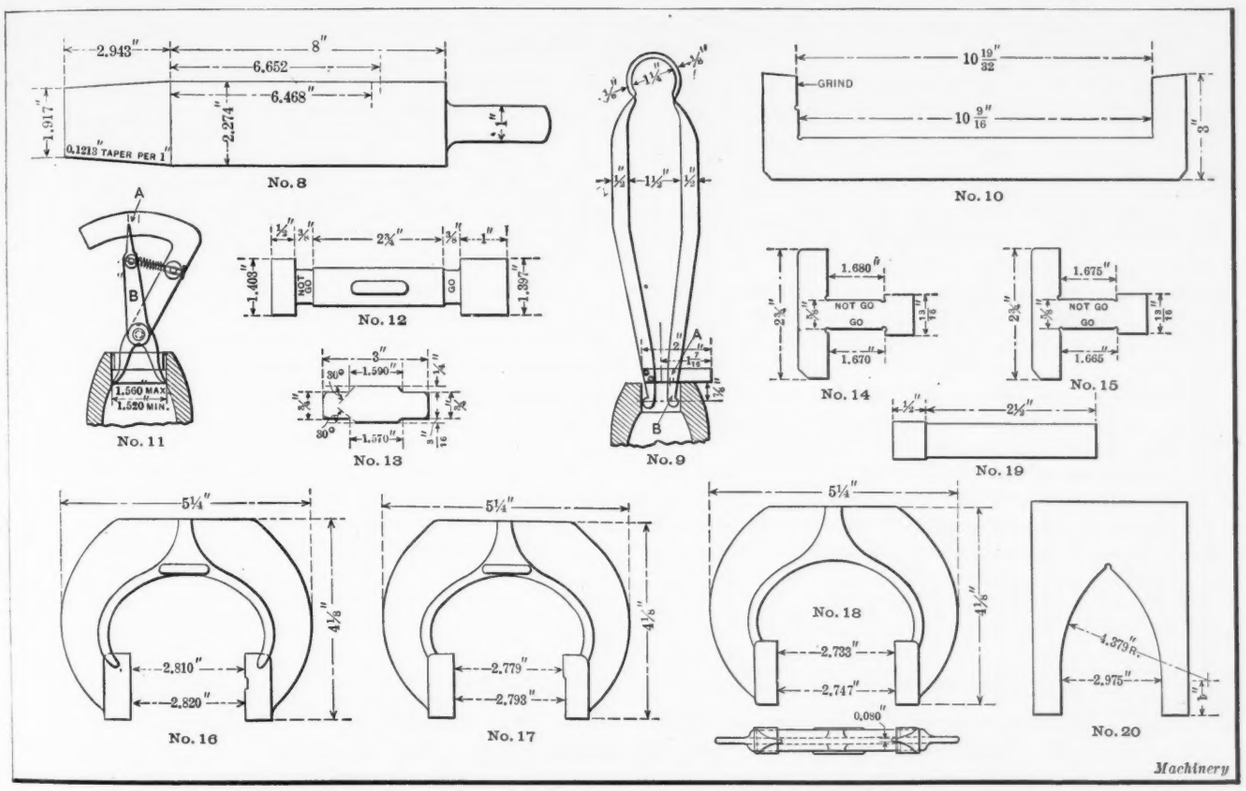


Fig. 2. Gages used in Inspection of U. S. 75-millimeter Shell referred to in Article as Nos. 8 to 20

After the shell has been rough- and finish-reamed and the inside bottom has been finished, it is inspected by gage No. 4 to test the diameter of the bore, and by gages Nos. 5 and 6 to determine the accuracy of the bottom. Gage No. 4 is a flat limit gage made from 3/16-inch stock, the lower end of which will enter and the upper end of which will not pass into the shell. Gage No. 6 must strike fully on the bottom of the shell. This is readily determined by the inspector, who can judge, both by sound and "feel," if the gage strikes fully on the bottom or stops against the side wall or bottom radius of the shell. Gage No. 5 is used in the same manner, but must stop against the side wall or bottom of the shell. In addition to the inspection by the gages, the inside of the shell is also subjected to a visual inspection for roughness of bore, by inserting an electric light into the bore. Two inspectors and one checker are employed at this inspection table.

The next inspection takes place after the second rough-turning of the entire outside, limit snap gage No. 7 being used. One inspector and one checker are employed on this inspection, the inspector also stamping on the shell a letter indicating the number of the working shift during which the shell was passed. The lot or code number of the forging is also transferred.

After the nosing-in operation, gage No. 9 is used for roughly determining that the opening at the end of the shell is of the right diameter. The lines at *A* on the cross-bar indicate the maximum and minimum limits between which the line *B* on the gage must come. The length of the shell after the nosing-in operation is also tested by the limit snap gage No. 10. After the heat-treatment, 10 per cent of the shells are subjected to a Brinell test, and physical tests of the metal are also made. These will be dealt with later.

Inspecting Machining Operations after Heat-treatment

The first machining operation after heat-treatment is the finishing of the base and the under-cutting of the boss for the center. The thickness of the base after this operation is tested by a fixture similar to that shown in Fig. 8, provided with a shoulder at the upper end of the measuring rod *A*, which must come between two limit shoulders *D* and *E* on the fixture when the thickness of the base is correct. The fixture used in the present operation, however, has a hole in the bottom at *B*, where the fixture in Fig. 8 is solid, to provide clearance for the boss for the center. One inspector both inspects and checks off the number of shells at this operation.

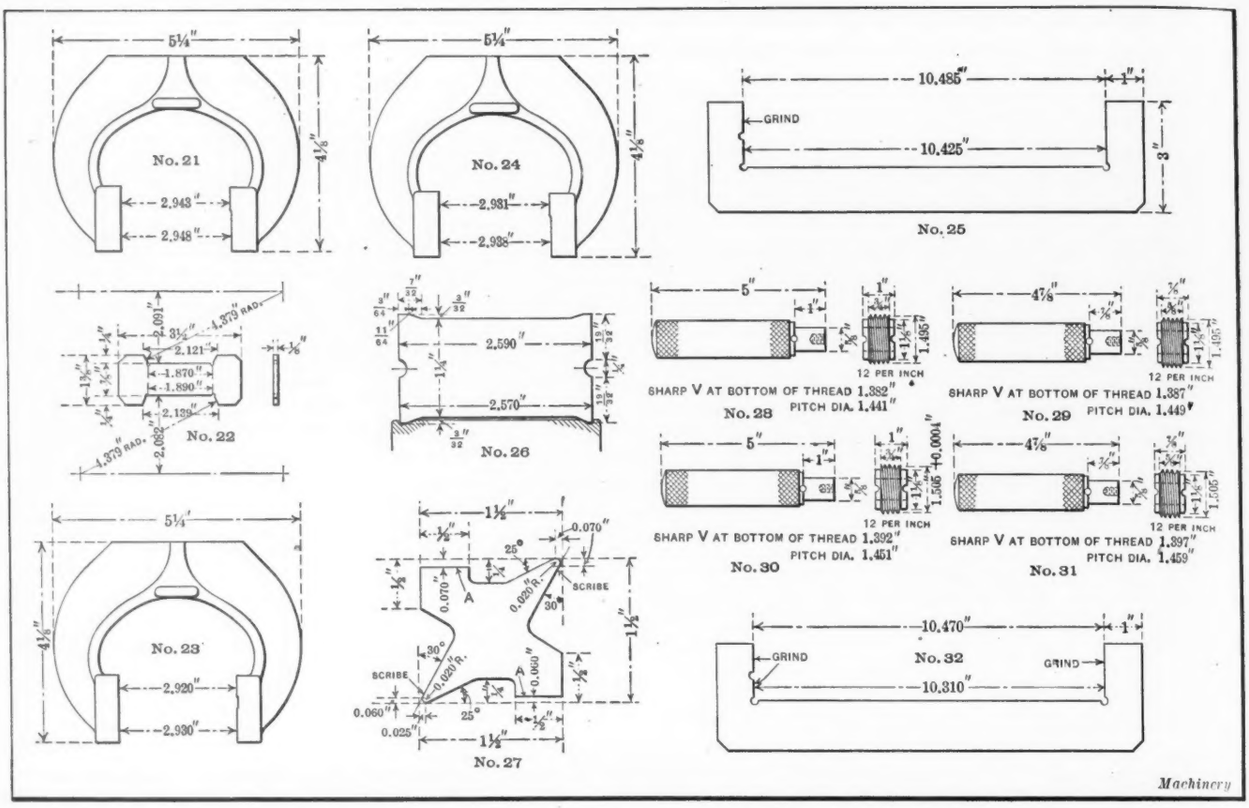


Fig. 3. Gages used in Inspection of U. S. 75-millimeter Shell referred to in Article as Nos. 21 to 32

The next machining operation consists of boring, recessing, facing, and beveling the hole for the fuse. These operations are inspected by gages Nos. 11, 12, and 13. Gage No. 11 checks the diameter of the recess below the thread. This gage has limit lines scribed on it at *A*, and if the diameter of the recess is within the prescribed limits, the pointer will indicate between these lines. Gage No. 12 checks the maximum and minimum diameter of the bore for the thread, while gage No. 13 checks the maximum and minimum diameter of the beveled part in the nose end. This gage is made from 1/8-inch flat stock. One inspector and one checker are employed for this work.

After the rough-grooving, the position of the groove for the band is tested by the limit snap gage No. 14. After the finish-grooving, a similar gage, No. 15, is used. The diameter of the band seat after the rough-grooving is inspected by the limit snap gage No. 16. A similar gage, No. 17, is used after the finish-grooving for testing the diameter in the center of the band groove, while gage No. 18 is used for testing the diameter at the sides of the finished band seat between the ridges in the bottom of the groove and the sides. It will be noted that the jaws of this gage are pointed so that they will enter into the narrow spaces between the ridges and the sides. Finally,

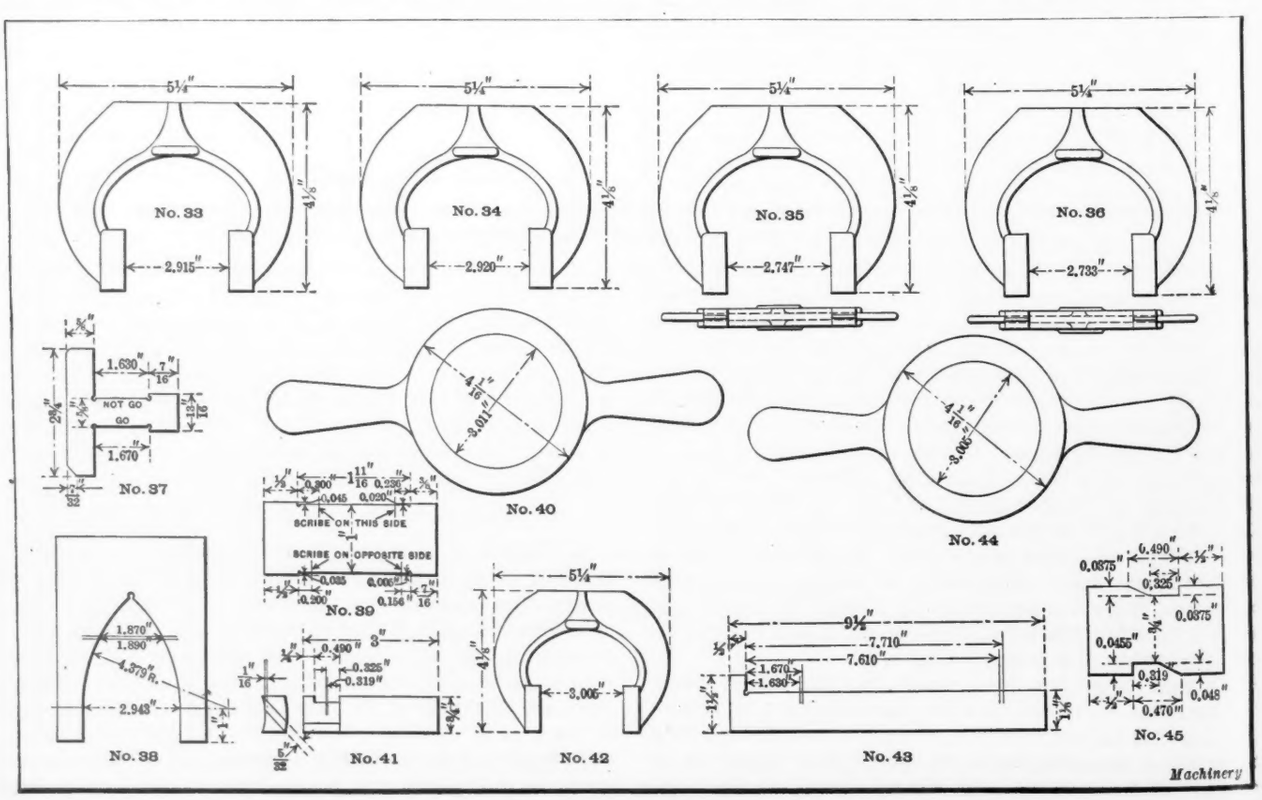


Fig. 4. Gages used in Inspection of U. S. 75-millimeter Shell referred to in Article as Nos. 33 to 45

gage No. 19 is used for testing the maximum and minimum width of the band groove. Two inspectors are employed in making these tests.

The next gaging operation is that of the rough-profiling of the nose of the shell, for which gage No. 20 is used. After the finish-profiling, the diameter of the bourrelet is gaged by the limit snap gage No. 21, Fig. 3, and the maximum and minimum diameter at the end of the nose by gage No. 22. At this time the stamp for the lot number is also changed from the base to the nose of the shell by a government inspector. Two inspectors are employed for this gaging, in addition to the government inspector.

Fig. 5. Table at which General Shop Inspection takes Place previous to Shells passing to Government Inspection Department

The body is now finish-turned above and below the band groove, gage No. 23 being used for testing the maximum and minimum diameter. On the side of the shell is now stamped the government code number corresponding to the number of the material stamped at the steel mill. After beveling the body for the cartridge case, the inspector checks the beveling by gage No. 39, Fig. 4, and also stamps the working shift number on the end of the shell in order to identify the shift during which the shell passed through these operations. The bourrelet is now ground, the diameter of the bourrelet after grinding being inspected by gage No. 24, Fig. 3. Two inspectors are employed for this work, and, in addition to gaging, they stamp the working shift mark on the shells.

After the refacing or finishing of the base surface, the total length of the shell is inspected by the limit snap gage No. 25, after which the groove in the base for the cover is cut. This groove is inspected by gages Nos. 26 and 27, which are both made from 1/16-inch flat stock. Gage No. 26 is a limit gage for testing the diameter of the groove, while gage No. 27 is a limit gage that is used for testing the depth and the undercut of the groove. The surfaces at *A* rest on the plain surface at the center of the base when making this test. There are two inspectors employed for making this inspection.

After the thread milling, the maximum and minimum thread gages Nos. 28 and 29 are used. It has also proved satisfactory to use a thread plug for the minimum dimension only, and to use a plain plug gage for the "Not Go" test. Gages Nos. 30 and 31 are the thread gages used for the final inspection after the thread has been sized. The difference between the four thread gages shown is simply in the dimensions of the thread. The lead of the thread of the gages must be accurate within a limit of 0.0002 inch in length of thread. Three inspectors are required for testing with threaded plug gages after the thread milling, and one inspector for testing with a plain "Not Go" plug gage. One checker is also employed for the inspection after the thread milling. The shells are now subjected to the hydraulic test, which is done under government supervision, and which will be dealt with later in connection with the general government inspection.

General Shop Inspection

The shell is now complete, except for the application of the copper band, and is subjected to a general shop inspection in which practically all the previous inspections are repeated. This inspection takes place at a long table, Fig. 5, with the inspectors seated at both sides. Before the inspection proper takes place, a visual inspection with a small electric lamp is made to see that the shells are clean on the inside. The diameter of the thread is measured by a "Go" thread gage

Fig. 6. Device for gaging Thickness of Base of Shells

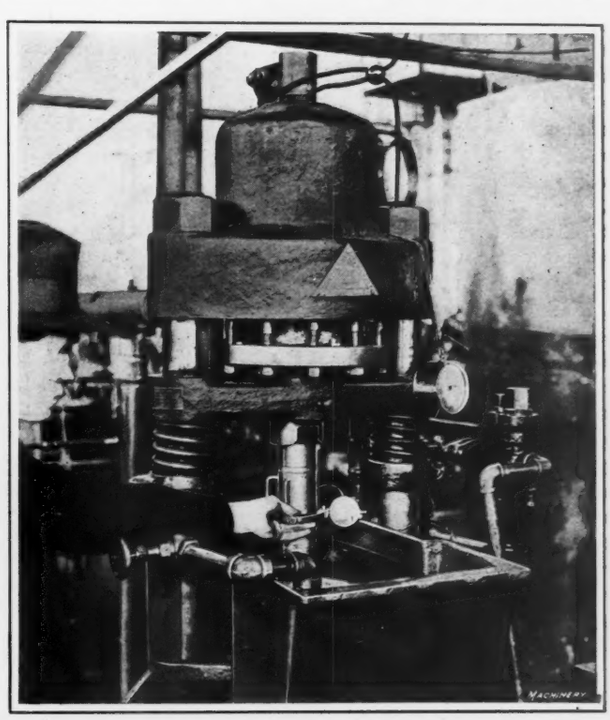


Fig. 7. Hydraulic Press Test of Shells made on Metalwood Mfg. Co.'s Press

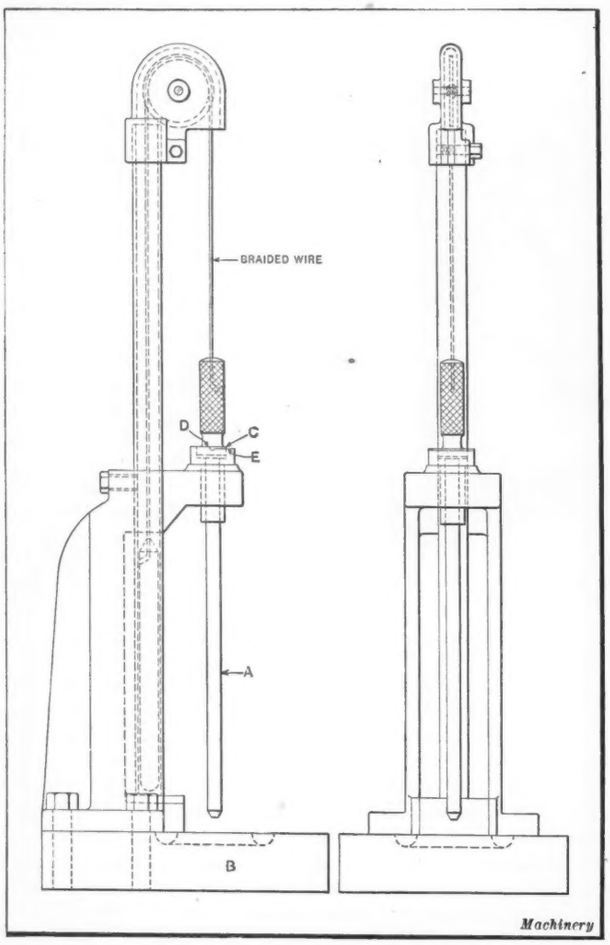


Fig. 8. Diagram of Device shown in Fig. 6, used for testing Thickness of Base of Shells

and a "Not Go" plain plug gage; and the length of the thread is inspected with a snap gage. The thickness of the base is gaged with the measuring machine shown in Fig. 8, the application of which is shown in Fig. 6. This measuring device is provided with a counterweight so that, when not used for gaging, plunger *A* will always be out of the way for the insertion of a shell on the base of the device. The inspector then grips the handle and pushes the plunger into the shell for gaging the thickness of the base. The shoulder at *C* is so located that it must always come between the two shoulders *D* and *E* when the thickness of the base is correct.

The total length of the body is gaged by the maximum and minimum snap gage No. 32, Fig. 3. The diameter of the body is gaged with a "Go" ring gage, as well as with a "Not Go" snap gage, No. 33, Fig. 4. The bourrelet is tested with a "Go" ring gage and a "Not Go" snap gage. The minimum diameter at the base is tested with snap gage No. 34. The band groove is inspected in the same way as after the finishing of the groove, except that two gages Nos. 35 and 36, one maximum and one minimum, are used. The maximum and minimum position of the band seat is tested by gage No. 37. The shell is inspected visually for roughness. The position of the bourrelet and the diameter of the nose are measured, and the profile of the nose tested, by gage No. 38. The length of the bevel at the base and band for the cartridge case is inspected by means of gage No. 39. The base groove and its shape are inspected by gages similar to those used after the machining operations. The thread of the fuse is inspected visually. The thickness of the wall is tested by the gage shown in Fig. 9, which has a movable measuring point *A* provided with a line which must come between two lines at *B* when the wall thickness is between the maximum and minimum limits. For this general shop inspection eighteen inspectors and seven helpers are employed. The capacity of the inspection table is 9000 shells in eight hours.

After this inspection, the shells pass immediately to the second or general government inspection, details of which will be given later. After this, the shells again enter the shop for pressing the copper band into place. After the band has been turned, the ring gage No. 40, Fig. 4, is used for the maximum or "Go" gage, while a "Not Go" snap gage is employed. Two inspectors are employed for the "Go" inspection and two for the "Not Go." In addition, the position of the band is tested by one inspector and the width of the band by another inspector, using gage No. 41. The "Not Go" snap gage for the copper band is shown as No. 42. The gage for the position of the band, which also tests the position of the bourrelet is made from 3/16-inch flat steel and shown as No. 43. In the government inspection the minimum diameter of the band is also measured by a ring gage No. 44. The profile and length of the band is tested by the gage No. 45.

Each operator of band turning machines has a red and blue electric light in front of him, and the inspectors have switches mounted on the inspection table so that they can light either lamp, according to whether the bands are high or low. In this way, the operator is immediately notified that he must readjust his tools. The blue light indicates a high band, and the red light, a low band.

After this inspection in the shop, the shells pass again into the government inspection department where the copper band is inspected, and then back into the shop for marking the number on the shells, lacquering, and packing into cartons. Previous to packing, the shell is given a visual inspection.

Government Inspection

The first government inspection, which takes place immediately before the nosing or bottling, has already been referred to. The next government test is that for the physical properties of the metal in the shell after heat-treatment. Two shells out of a thousand are selected, a test piece being cut from each and subjected to tests to determine the elastic limit, ultimate strength, and elongation; an Olsen testing machine is used. The test piece must show a minimum elastic limit of 45,000 pounds per square inch, a minimum ultimate tensile strength of 90,000 pounds per square inch, and an elongation of 15 per cent in two inches. Ten per cent of the shells are also subjected to a Brinell test on an Olsen hardness testing machine. This test is, strictly speaking, only an additional check on the physical test. One government inspector on each shift observes the Brinell tests and reads off the diameter of the impression made by the test ball in the shell. A flat surface must be ground on the shell for this test, ½ inch below the bourrelet. The pressure of the testing machine is 3000 kilograms, which is applied for thirty seconds. The depression should be between 3.8 and 4.2 millimeters, corresponding to Brinell hardness numbers 255 and 207. This test merely determines whether or not the steel is too hard to machine, and there are practically no rejections at this point if the lot of heat-treated shells has passed the physical tests. Should a shell not pass the Brinell test, it is still accepted if it passes the hydraulic test applied later.

Hydraulic Test

Ten per cent of the shells are subjected to a hydraulic test on a Metalwood Mfg. Co.'s shell-testing hydraulic press as shown in Fig. 7. A gage is held so that the expansion of the shell while under pressure will be indicated on an ordinary dial indicator. The pressure is 10,000 pounds per square inch and the shell is subjected to this pressure for fifteen seconds. After the test, the dial indicator must not show a permanent

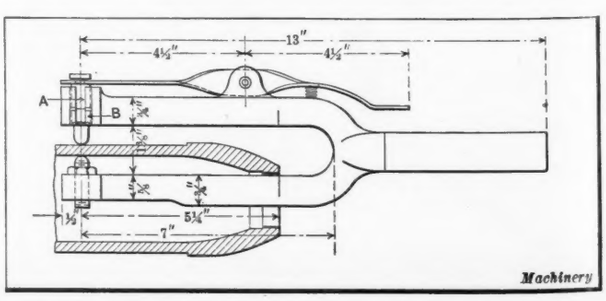


Fig. 9. Gaging Device used for determining Thickness of Wall of Shells

set of the shell exceeding 0.003 inch. While the pressure is on, the expansion of the shell may be from 0.004 to 0.006 inch. Seldom, however, does the permanent set reach the limit prescribed, but it ordinarily averages between 0.00025 and 0.0005 inch. Very few shells ever fail in this test. The company operates this test, but a government inspector uses the inspecting gage.

Second or General Government Inspection

All the government inspection in this plant is under the direction of J. M. Lennon, chief army inspector of the United States Government at the American Shell Co. The gages used are mainly the same as those employed in the general shop inspection by the company, but in addition a number of other tests are made. The government inspection room employs thirty-two inspectors, all of whom are women, and has a capacity for inspecting 8000 shells in eight hours. The shells enter the government inspection room from the shop inspection table on a conveyor and are automatically counted when entering. The inspection continues, each inspector checking one dimension only, and marking the shells if not passed. At the end of the inspection table a sorter is placed who picks out the marked shells and puts them on a temporary rejection table from which they are sent back into the shop for repairs. Upon entering the inspection room the shells are first inspected visually on the interior and on the outside for cracks, seams, and flaws, a magnifying glass being used for this purpose. A ringing test is also made with a small four-ounce hammer. A dull sound indicates cracks. The fuse hole thread is next inspected by means of a special gaging machine designed by the American Shell Co. The thread gage is held by hand, but the shell is rotated. By pressing a foot-lever, the direction of rotation will be reversed, so that the gage is unscrewed. An automatic knock-out pushes the shell out of the chuck that holds it during this operation. The machine has a capacity for gaging 4000 shells in eight hours.

After this test, the following inspections are made in the government inspection room: Diameter of band groove ("Go" and "Not Go" snap gage); diameter of body above band ("Go" and "Not Go" snap gage); diameter of body below band ("Go" and "Not Go" snap gage); diameter of bourrelet ("Not Go" snap gage); position of band groove ("Go" and "Not Go" snap gage); width of band groove ("Go" and "Not Go" plug gage); position and angle of taper for cartridge case ("Go" and "Not Go" snap gage); position of band groove and bourrelet ("Go" and "Not Go" hook gage); diameter of recess below thread (limit gaging fixture); length over all of shell body ("Go" and "Not Go" snap gage); wall thickness (limit gaging fixture); diameter of bourrelet ("Go" ring gage); outside diameter of base of shell ("Go" and "Not Go" profile gage); root diameter of fuse hole thread ("Not Go" plug gage); length of thread ("Go" and "Not Go" snap gage); profile of shell nose ("Go" profile gage); length of recess below thread (limit gaging fixture); thickness of base (limit gaging fixture); diameter of rear of band ("Go" ring gage); diameter of base cover groove ("Go" and "Not Go" snap gage); depth of base cover groove ("Go" and "Not Go" gage).

Shells which are within the limits of accuracy allowed pass directly to a stamping machine where the government stamp is placed upon them. A Bliss No. 8 power press is used for this purpose, provided with a knock-out which throws the shell automatically onto a belt conveyor, carrying it back into the shop, the shells being counted automatically as they pass out.

Final Government Inspection

The third or final government inspection which takes place after the copper bands have been pressed into place and turned to the correct shape consists in counting the shells as they enter the government inspection room and then gaging the diameter of the band ("Go" ring gage and "Not Go" snap gage); the profile of the band ("Go" and "Not Go" profile gage); and the position of the finished band ("Go" and "Not Go" snap gage). The shells at this time are also placed into a so-called "coffin gage," which is made 0.005 inch over the maximum dimensions in all directions and in which the shell is rolled to see that it is within this limit. It is also tested with a concentricity gage having a threaded plug which enters the fuse hole and which indicates that the body of the shell is concentric with the thread. The shells are next weighed by being rolled over the platform of a Toledo platform scale arranged for this purpose; 15,000 shells can be weighed in this way in eight hours. The weight must be correct between the limits of 9 pounds 3½ ounces and 12 pounds 3½ ounces. The shells are then stamped with a government stamp, counted, and passed out for packing and shipping.

Additional Government Inspections

In addition to the inspection activities detailed in the foregoing paragraphs, the Government employs one man who checks the number of forgings received with the government shipping list. The company makes out a requisition to this inspector before the forgings pass into the shop. This man also attends to the shipping of the finished shells and observes the packing of the shells. Another government inspector is employed on each shift for observing the heat-treatment. Every half hour he takes a reading of the pyrometer of each furnace and notes the company's manner of heat-treatment for each shell. He also takes out the shells required for the physical tests.

One government inspector in each shift transfers the government stamp indicating the heat number of the forging from the body to the base after the finish-profiling of the nose. One man is also employed on each shift for transferring the same mark from the base to the body after the grinding of the bourrelet.

On all the government inspection where gages are used, duplicate gages are employed, so that when one or two of the gages are in use, one or two duplicate gages are checked by the government gage checker. A view in the government inspection room is shown in the heading illustration. At the time when this article was prepared, A. G. Preen was chief army inspector at the American Shell Co., and the author is indebted to him for the information relating to the government inspection in the plant.

* * *

EMPLOYMENT OF GIRLS IN DRAFTING-ROOM

Women workers have entered not only into the shop, but also into the drafting-room. There are a number of firms who have employed girls as tracers for a period long enough to determine the success of the arrangement. Among these is the Reed-Prentice Co., Worcester, Mass., where women have been employed in the drafting-room for over a year. The idea that girls could be so employed was conceived by F. K. Hendrickson, mechanical engineer of the company, who about a year ago, engaged eight girls, starting them on tracing. These girls had no previous experience, but the experiment has proved so successful that now practically all the tracing of the company is done by girls, and it has been found that the most experienced can trace any drawing handled in the company's drafting-room. In fact, the management of the Reed-Prentice Co. is quite enthusiastic about the experiment. The girls on the whole work more rapidly than the men formerly employed, and the quality of the work will, in the long run, be fully as good, if not superior, to that turned out by the men tracers. An indication of the progress made is shown by the fact that one girl has already left the employ of the company to take charge of the tracing department with another concern. It is, of course, evident that tracing is a class of work for which women could be assumed to be unusually well fitted, and it is quite likely that as the war demands the services of more and more young men either at the front or in capacities in the shop for which men are better fitted than women, a greater number of girls will be employed in drafting-rooms.

* * *

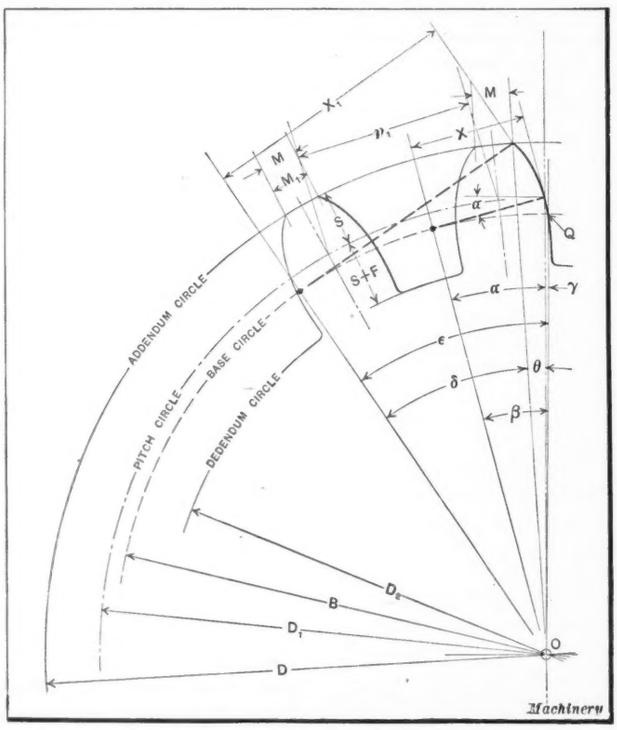
A recently patented bearing alloy, which, it is claimed, requires little lubrication, contains copper, 4 parts; antimony, 2 parts; nickel, 1 part; and lead, 1 part.

THICKNESS OF INVOLUTE GEAR TEETH ON ADDENDUM CIRCLE

A METHOD OF ACCURATELY GENERATING SILENT GEARS

BY REGINALD TRAUTSCHOLD [1]

THE degree of perfection demanded of gearing for use in the high-class modern automobile has materially elevated the plane of commercial gear cutting, and has, at the same time, drawn attention to certain faults that had previously passed unnoticed or unheeded. Automobile gears must be accurate in every respect, or they will be noisy and give trouble. Accuracy means, above all else, that the teeth of the gears are identical and correctly proportioned. Measurements are perforce made on the pitch circle of the gears, the elusive dimension that governs the speed ratios, etc., but the difficulties of accurately measuring the pitch diameter have not proved insurmountable. The measurement of the distance between pins proportioned so as to rest on the pitch lines of adjacent spur gear teeth, placed in diametrically opposite tooth spaces, accurately checks the pitch diameter; the outside gear diameter and the dedendum diameter can also be accurately checked. Notwithstanding accuracy in pitch diameter, addendum, and dedendum dimensions, there is hardly an automobile manufacturer who has not been troubled with noisy gears. Some sets of gears, apparently as carefully cut as is commercially possible, with all pitch dimensions accurate and the addendum and dedendum dimensions correct will not run together quietly, while other sets, cut on the same machines and with the same care, will run together with much less noise. This is quite a common experience and can only be explained by variations in the profiles of meshing teeth. But a slight variation in the pressure angle of the teeth of the respective gears will cause appreciable noise.



Top Measurement of Involute Spur Gear

The spur gears used in automobile construction, with which the greater amount of annoyance is encountered, are almost exclusively of the type with teeth cut to the involute standard. The very simplicity of this involute curve is probably responsible in large measure for the prevalent errors, for, though lending itself admirably to generating processes, it is governed by inflexible conditions of obliquity, which, if deviated from in the least degree will result in sufficient variation in tooth profiles to cause unsatisfactory gear operation. The profiles of all involute gear teeth are developments of a rack tooth with perfectly flat sides inclined to its center line at a definite angle of obliquity, or pressure angle, so that variations in profile curvature are due to a difference in pressure angle of the developing rack tooth.

There are three general methods of cutting gear teeth: with regular standard involute cutters; by the Fellows gear-shaper method; and with generating machines of the Bilgram gear-generating machine variety. Each of these is open to the possibility of error in maintaining a constant and correct pressure angle.

The use of standard rotary involute cutters results in error to the greatest extent, for, whether the eight-cutter or the fifteen-cutter set is employed, it is impossible for a rotary cutter to be correct for more than one specific number of teeth. For instance, a No. 4 cutter, in the eight-cutter set, cannot be correct for thirty-four teeth if correct for twenty-six teeth; nor, in the fifteen-cutter set, correct for twenty-nine teeth as well as for twenty-six teeth. If the cutter is correct for twenty-six teeth, only twenty-six tooth gears can be accurately produced with it. Add to this the possibility of a slight alteration in the cutter profile each time the tool is ground and the difficulties of producing gears with teeth of accurate pressure angle with standard rotary involute cutters can be easily recognized.

In the case of the Fellows gear shaper, chances for error are greatly reduced, for the teeth of the cutter are accurately ground after hardening to true involute form. This assures the production of true and accurately proportioned involute gear teeth, and the teeth of the cutter retain their correct shape as the cutter is sharpened. The reason for this is that the involute curve has the virtue of running correctly at varying center distances. Therefore, as the cutter is ground down by sharpening, it is operated with the gear blank at a different center distance than when it was new, but still produces exactly the same tooth shape. Noisy gears in automobile transmission boxes are caused mostly by inaccuracies in the location of the shafts and the mounting of the gears.

The use of a truncated, straight-sided cutting tool, such as that employed in the Bilgram spur-gear generating machine, permits the regrinding of the cutting edges of the tool with more accuracy and less difficulty than is possible when sharpening form cutters. For this reason, gears generated by Bilgram machines are less liable to variations in pressure angle, though the danger is not entirely eliminated. The slope of both sides of the reciprocating tool must be similar and constant to assure uniformity of output, so there always remains a possibility of variation in pressure angle, even in the gears generated on Bilgram machines.

The chances for variation in the pressure angles of spur gearing, no matter how efficiently the gears are produced, have been emphasized in order to show the importance of accurate checking of the pressure angles of any spur gearing that must be precise to be satisfactory. The logical check for this highly important consideration is the circular thickness of the involute teeth on the addendum circle, for any generated spur gear tooth or one cut with a standard involute cutter that is correct on both the pitch circle and the addendum circle must also be correct as far as pressure angle is concerned, provided the diameters of these circles are also correct.

The illustration shows the dimensions that must be calculated in the derivation of an equation by which the circular thickness M of the involute tooth on the addendum circle can be readily ascertained. The formula to be presented is based on the facts: (1) that a normal to any point on the tooth profile, between the base and the addendum circles, will be tangent to the base circle; (2) that for similar gears there is a constant ratio between the lengths of tangents between similar points of contact on the tooth profiles and their points of tangency on the base circles; (3) that there is a constant ratio

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between the angles subtended between radial lines to the intersection of the profile tooth curves with the base circles and radial lines to the tangent points on the base circles of normals to similarly located points on the same tooth profiles of similar gears.

Notation

Pitch diameter	D_1
Addendum	S
Dedendum	$S + F$
Outer diameter	D
Base circle diameter	B
Dedendum circle diameter	D_2
Pressure angle	α
Normal to pitch circle, length	X
Angle subtended by arc equal to normal to pitch circle	β
Angle difference between β and α	γ
Thrust angle at top of tooth	δ
Normal to addendum circle, length	X_1
Angle subtended by arc equal to normal to addendum circle	ϵ
Angle difference between and $\delta + \gamma$	θ
Thickness of tooth on addendum circle	M
Chordal thickness of tooth on addendum circle	M_1
Backlash, total	L
Backlash angle	λ
Thickness of tooth with backlash on addendum circle	M_2
Number of teeth	N
Diametral pitch	p
Circular pitch	p_1

Derivation of Formulas

$$B = D_1 \cos \alpha \tag{1}$$

$B = 0.96815\, D_1$, 14.5-degree involute tooth (2)

$B = 0.93969\, D_1$, 20-degree involute tooth (3)

$$X = 0.5\sqrt{D_1^2 - B^2} = 0.5\sqrt{D_1^2 - (D_1 \cos \alpha)^2}$$

$$X = 0.5\, D_1 \sqrt{1 - (\cos \alpha)^2} \tag{4}$$

$X = 0.12508\, D_1$, 14.5-degree involute tooth (5)

$X = 0.17099\, D_1$, 20-degree involute tooth (6)

$$\beta = \frac{360\, X}{3.1416\, B} = \frac{57.296\sqrt{1 - (\cos \alpha)^2}}{\cos \alpha} \tag{7}$$

$\beta = 14.8046$ degrees, 14.5-degree involute tooth (8)

$\beta = 20.8527$ degrees, 20-degree involute tooth (9)

$$\gamma = \beta - \alpha \tag{10}$$

$\gamma = 0.3046$ degrees, 14.5-degree involute tooth (11)

$\gamma = 0.8527$ degrees, 20-degree involute tooth (12)

$$D = D_1 + \frac{2}{p}, \text{ standard proportions} \tag{13}$$

$$X_1 = 0.5\sqrt{D^2 - (D_1 \cos \alpha)^2} \tag{14}$$

$X_1 = 0.48408\sqrt{1.0667\, D^2 - D_1^2}$, 14.5-degree involute tooth (15)

$X_1 = 0.46985\sqrt{1.1325\, D^2 - D_1^2}$, 20-degree involute tooth (16)

$$\epsilon = \frac{360\, X_1}{3.1416\, D_1 \cos \alpha} = \frac{114.59\, X_1}{D_1 \cos \alpha} \tag{17}$$

$$\epsilon = \frac{57.296\sqrt{1.0667\, D^2 - D_1^2}}{D_1}, \text{ 14.5-degree involute tooth} \tag{18}$$

$$\epsilon = \frac{57.296\sqrt{1.1325\, D^2 - D_1^2}}{D_1}, \text{ 20-degree involute tooth} \tag{19}$$

$$\text{Sin } \delta = \frac{2\, X_1}{D} \tag{20}$$

$$\theta = \epsilon - (\gamma + \delta) = \epsilon - \gamma - \delta \tag{21}$$

$\theta = \epsilon - \delta - 0.3046$ degrees, 14.5-degree involute tooth (22)

$\theta = \epsilon - \delta - 0.8527$ degrees, 20-degree involute tooth (23)

$$M = \left(\frac{180}{N} - 2\theta\right)\frac{3.1416\, D}{360}$$

$$M = \frac{(1.5708 - 0.01745\, \theta N)\, D}{N} \tag{24}$$

$$\text{Tan } \lambda = \frac{0.5\, L}{D \cos \delta} \tag{25}$$

$$M_2 = M - 2\left(\frac{3.1416\, D\lambda}{360}\right) = M - 0.0175 D\, \lambda$$

(λ in degrees) (26)

$$M_1 = D \sin \frac{57.296\, M}{D}, \text{ 14.5 degrees, with no backlash} \tag{27}$$

$$M_1 = D \sin \frac{57.296\, M_2}{D}, \text{ 20 degrees with backlash} \tag{28}$$

Discussion of Formulas

The length of the normal X to the pitch circle, that is the length of the tangent from the point of tangency on the base circle to its normal contact on the pitch line of the tooth profile, is equal to one-half the square root of the difference between the square of the pitch diameter and the square of the diameter of the base circle. As the diameter B of the base circle is equal to the pitch diameter D_1 multiplied by the cosine of the pressure angle α, the length of the normal X to the pitch circle is a definite proportion of the pitch diameter D_1.

The angle β subtended between a radial line to the intersection Q of the base circle with the tooth profile and a radial line to the point of tangency on the base circle of the normal to the pitch circle is measured by an arc of a length equal to the length of the normal to the pitch circle. The difference between this angle β and the pressure angle α is equal to the angle γ between a radial line to the pitch line on the profile of the tooth and the radial line to the intersection Q of the base circle with the same tooth profile.

The length of the normal X_1 to the addendum circle, that is the length of the tangent from the point of tangency on the base circle to its normal contact on the tooth profile at the addendum circle, is equal to one-half the square root of the difference between the square of the outer diameter D of the gear and the square of the diameter B of its base circle.

The angle ϵ subtended between a radial line to the intersection Q of the base circle with the tooth profile and a radial line to the point of tangency on the base circle of the normal to the addendum circle is measured by an arc of length equal to the length of the normal X_1 to the addendum circle. The difference between this angle ϵ and the sum of the angle γ between a radial line to the pitch line on the profile of the tooth and a radial line to the intersection Q of the base circle with the same tooth profile and the thrust angle δ at the top of the tooth measures the angle θ subtended by the involute tooth profile between the pitch and addendum circles.

The thrust angle δ at the top of the tooth is the angle included between the plane of pressure at the top of the tooth and a plane tangent to the addendum circle at that point. Its sine is equal to twice the length of the normal to the addendum circle divided by the outer diameter of the gear.

The angle subtended on the addendum circle by the top of the involute teeth is then equal to one-half the pitch angle (180 divided by the number of teeth) minus twice the angle subtended by the involute profile of the tooth between the pitch and addendum circles. The angle subtended by the top of the tooth on the addendum circle multiplied by the outer circumference of the gear divided by 360 gives the circular thickness of the involute tooth on the addendum circle.

The chordal thickness M_1 of the involute tooth on the addendum circle is equal to twice the outer radius multiplied by the sine of half the angle subtended by the circular thickness of the tooth on the addendum circle, or is equal to the product of the outer diameter of the gear by the sine of half the same angle.

The backlash angle λ, twice which must be subtracted from the angle subtended on the addendum circle by the top of an involute tooth without backlash to obtain the angle subtended on the addendum circle by the top of an involute tooth with backlash, is the angle the tangent of which is the quotient of one-quarter the total amount of backlash L divided by the cosine of the thrust angle δ at the top of the tooth divided by one-half the outer diameter D of the gear. This equation can be

simplified to the form: the tangent of the backlash angle λ equals one-half the total backlash L divided by the product of the outer diameter D of the gear multiplied by the cosine of the thrust angle δ at the top of the tooth.

The circular and chordal thicknesses on the addendum circle of involute teeth with backlash are then obtained from the angle subtended on the addendum circle by the top of the teeth with backlash.

Formula (24) gives the value of the circular thickness of true involute teeth on the addendum circle, which are also correct in their circular thickness on the pitch circle, that is, for gears with no backlash. It is advisable at times to allow a certain amount of backlash, however, and this seriously affects the circular thickness of the teeth on the addendum circle; though, if the backlash is properly provided for, there will be no modification in the angles subtended by the lengths of the normals to the tooth profiles, as measured along the base circle from their respective points of tangency on that circle. When a definite amount of backlash is provided for, the backlash should be divided between the two engaging gears so that one-half is provided by the decrease in the thickness of the teeth and one-half in the increased width of the tooth spaces; that is, a quarter of the total backlash is removed from each of the profiles of engaging and correctly proportioned teeth. The thickness of metal removed to provide the desired play must be normal to the tooth profiles and of constant thickness, so that the reduction in circular thickness of the teeth on the addendum circle is much more marked, for a given amount of backlash, than the reduction in the circular thickness of the teeth on the pitch circle. The increased reduction in the circular thickness, due to the fact that the angularity of the pressure angle at the corner of the tooth on the addendum circle—referred to as the thrust angle δ at the top of the tooth to distinguish it from the pressure angle α at the pitch circle—is considerably greater than the pressure angle α at the pitch line of the teeth, materially facilitates accurate measurement of backlash. Backlash that would be scarcely noticeable on the pitch circle becomes quite apparent when measured on the addendum circle. Fomula (26) gives the circular thickness M of involute teeth on the addendum circle with backlash proportioned equally between the teeth and the tooth spaces of involute spur gears.

Although measurements on the addendum circle are obviously made with a greater degree of accuracy than corresponding measurements can be made on the pitch circle, provided, that the addendum dimensions of the gear are accurate, even greater accuracy can be secured by taking chordal measurements than by circular measurements. Reliance on chordal measurements permits the use of simple gages with high and low limits for checking purposes.

Example—Required the thickness of the teeth on the addendum circle of a standard 25-tooth involute gear, 5-inch pitch diameter, and 20-degree teeth, with 0.002 inch backlash.

$$D = 5 + \frac{2}{5} = 5.4 \text{ inches} \qquad (13)$$

$$X_1 = 0.46985\sqrt{1.1325 \times 29.16 - 25} = 1.3309 \text{ inch} \qquad (16)$$

$$\epsilon = \frac{57.296\sqrt{1.1325 \times 29.16 - 25}}{5} = 32.4593 \text{ degrees} \qquad (19)$$

$$\text{Sin } \delta = \frac{2 \times 1.3309}{5.4} = 0.4929 \qquad (20)$$

$$\delta = 29 \text{ degrees } 32 \text{ minutes}$$

$$\theta = 32.4593 - 29.5333 - 0.8527 = 2.0733 \text{ degrees} \qquad (23)$$

$$M = \frac{(1.5708 - 0.01745 \times 2.0733 \times 25)\ 5.4}{25} = 0.1439 \text{ inch} \qquad (24)$$

$$\text{Tan } \lambda = \frac{0.5 \times 0.002}{5.4 \times 0.87007} = 0.00021 \qquad (25)$$

$$\lambda = 0 \text{ degrees } 0 \text{ minutes } 44 \text{ seconds}$$

$$M_2 = 0.1439 - 0.0175 \times 5.4 \times 0.01222 = 0.14275 \text{ inch} \qquad (26)$$

$$M_1 = 5.4 \sin \frac{57.296 \times 0.14275}{5.4} = 5.4 \times 0.02643 = 0.1427 \text{ inch} \qquad (28)$$

The example cited, the conditions governing which are very similar to the requirements for the main driving pinion of a leading type of motor truck, forcibly brings out the accuracy in checking pitch-circle measurements by measurements taken on the addendum circle. A backlash of 0.002 inch is specified; that is, a reduction of 0.001 inch in circular thickness of the teeth on the base circle is called for. Such a small reduction in the standard thickness of the tooth could be measured only with difficulty on the pitch circle, but when measured on the addendum circle the reduction in circular thickness amounts to approximately 1/64 inch, an amount that can readily be measured. The multiplication of such dimension is by no means constant, of course, as it is dependent upon the number of teeth and the addendum dimension of the gear, but in every case the dimension is considerably larger when measured on the addendum circle than on the pitch circle.

The aggravation of profile variations on the addendum circle shows up accurately any variation from the specified pressure angle. An increase in pressure angle, although other proportions are correct on the pitch circle, will result in quite an appreciable reduction in the circular thickness of the teeth on the addendum circle; while a decrease in pressure angle will be apparent by a noticeable increase in the circular thickness of the teeth. A very slight variation in pressure angle, such as may readily be caused through the resharpening of the cutting tool, will cause an apparent variation in the circular thickness of the teeth on the addendum circle.

In fact, so accurately will any variations in pressure angle, backlash, etc., of involute gear teeth be shown by check dimensions made on the addendum circle that the addition of the required circular, or chordal, thickness of the teeth on the addendum circle to the specifications for precise gearing will eliminate much of the present trouble due to noisy and unsatisfactory gearing. As an inspection check for manufacturers of accurate gearing, it will definitely establish the correctness of the cutting edges of generating tools, etc., and will allow the manufacturer to guarantee with assurance, the silent operation of his accurately generated gears, when properly mounted. The justifiable objections of his customers will be greatly reduced, if not entirely eliminated, and danger of possible rejection of consignments avoided. High-class generating machines, built on theoretically correct principles, will become more valuable and more efficient, as the correct proportions of their generating tools can be assured.

* * *

LAY-OUT FOR MULTIPLE-SPINDLE DRILLS

The weakest feature of multiple-spindle drills of the cluster type is the universal joints in the spindles. A universal joint should never be run at an angle much greater than 30 degrees, but there are many drilling machine operators who do not realize how important it is to avoid setting the spindles so that the joints exceed this angle. The result of excess angularity is worn and broken joints and dissatisfaction with the machine. The National Automatic Tool Co., of Richmond, Ind., provides with each machine sold for a special job a chart showing the lay-out of the spindles and the position of the spindle holders. The cluster plate is reproduced in a drawing on a large fiber sheet, the proper spindle groups being shown, so that no one need go wrong. The result of this practice is that the machines are set up in accordance with the manufacturer's plan, and no universal joint is set at an angle beyond which it should not be worked. This means long life of the joints and better satisfaction all around.

* * *

It is reported that an invention has been made by the Lux Co., in Stockholm, Sweden, making it possible to use alcohol made from sawdust and other wood refuse in engines designed for gasoline. By introducing acetylene into the alcohol, satisfactory ignition qualities are obtained. It is stated that, by adding from five to six pounds of calcium carbide to 100 pounds of 92-per cent alcohol, acetylene is produced which is absorbed by the alcohol, and the resulting mixture has the required qualities for use in automobiles designed for gasoline. Automobiles can make use of this mixture without any change whatever in the engine. The invention is said to be fully developed, and has been patented by H. Rustige.

THREAD ROLLING

CONCLUDING INSTALLMENT OF A SERIES ON DIFFERENT METHODS OF FORMING SCREW THREADS BY ROLLING, VARIOUS TYPES OF THREAD-ROLLING MACHINES, ADVANTAGES OF ROLLING PROCESS, AND GENERAL APPLICATION

BY FRANKLIN D. JONES[1]

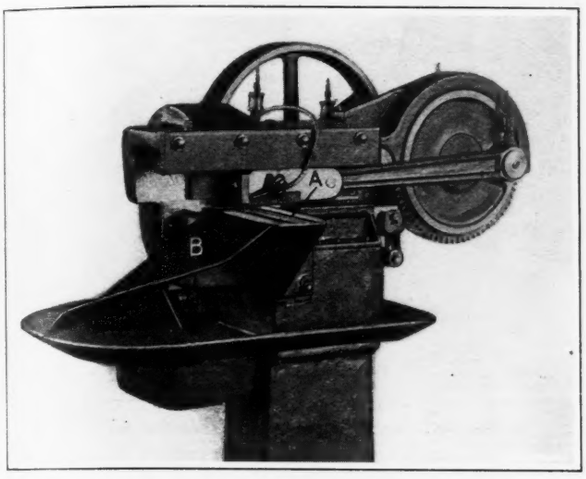


Fig. 16. Side-feed Type of Thread-rolling Machine designed for rolling Threads on Ends of Slender Wire Rods, etc.

THE general method of rolling screw threads between flat dies was described in the first installment of this article (see the April number, page 690) which included information on reciprocating thread-rolling machines of the type which has been used extensively, the adjustment of these machines, the operation of semi-automatic and automatic blank feeding mechanisms, and some of the more important features of the thread-rolling process. In this concluding installment, other types of thread-rolling machines are described, and the advantages and range of the thread-rolling process are considered. As thread rolling is sometimes done in automatic screw machines or turret lathes, the article deals with the special tools and method utilized in connection with this branch of thread-rolling practice.

Side-feed Type of Thread-rolling Machine

The design of thread-rolling machine shown in Fig. 16 is intended especially for rolling threads on the ends of comparatively long slender parts, such as wire rods, the spokes of wire wheels, and other similar classes of work which cannot be handled to advantage in a machine in which the work is held vertically while the thread is being rolled. With the side-feed type of machine, the work is rolled while in a horizontal position so that long slender parts can be operated upon without difficulty. When this machine is in operation, the blanks to be threaded are placed against edge *A* on the table bracket and against a depth gage which may be adjusted for any length within the capacity of the machine. The part to be threaded is then started between the dies automatically by means of a push-finger the same as on the machines previously referred to. As each threaded part leaves the dies it rolls down the inclined plate *B* and into a receptacle.

Vertical Type of Thread-rolling Machine

The thread-rolling machine made by the National Machinery Co., Tiffin, Ohio, is a vertical design. This machine (see Fig. 17) occupies a comparatively small floor space and it is claimed that the dies, which are also in a vertical position, last longer than horizontal dies because the scale and foreign matter are more readily washed away by the lubricant, which continually floods the dies. The front and side elevations of the machine shown in Fig. 18 illustrate the arrangement of the different parts. The stationary die is located at *A* and is provided with adjustments at the side and back. The reciprocating slide which carries the moving die *B* is operated by a yoke *C* connecting with the crankshaft of the machine. This yoke is pivoted at *D* and engages block *E* mounted on the crank-pin. The oscillating motion of yoke *C*, which is connected with the reciprocating slide by rod *F*, gives a slow downward stroke to the die and a quick return movement.

The blank upon which a thread is to be rolled is inserted horizontally in a gap between the dies at the top and against the end of gage *G* at the rear. Then the starter *H* which derives movement from cam *J* on the main shaft, pushes the blank between the dies at the right moment, after which the downward motion of the moving die causes the blank to roll between the dies until it drops out at the lower end with a complete thread formed on it. In order to reduce friction and wear to a minimum, the movable slide is backed by a train of hardened steel rollers *K*. The frame carrying these rollers is moved up and down by the double rack and pinion mechanism shown at *L*. The machine is driven by a belt operating on the flywheel pulley *M* which drives the crankshaft through pinion *N* and gear *O*. This flywheel is not positively connected to its shaft but drives through frictional surfaces which act as a safety relieving device for the machine. For instance, if the dies should become loose through neglect on the part of the operator or the machine should stall as the result of some accident, the flywheel would slip between the friction flanges and thus dissipate its excess energy so as to avoid damaging the parts of the machine. A lubricating pump *P* connecting with the oil reservoir *Q* keeps the dies flooded continually with oil, thus removing scale and dirt from the grooves in the die faces.

Rotary Thread-rolling Machine

The rotary thread-rolling machine made by the Acme Machinery Co., Cleveland, Ohio, differs radically in its design from the types previously described. This rotary machine, which is illustrated in Fig. 19, is so called because one of the dies revolves continuously in one direction. This revolving

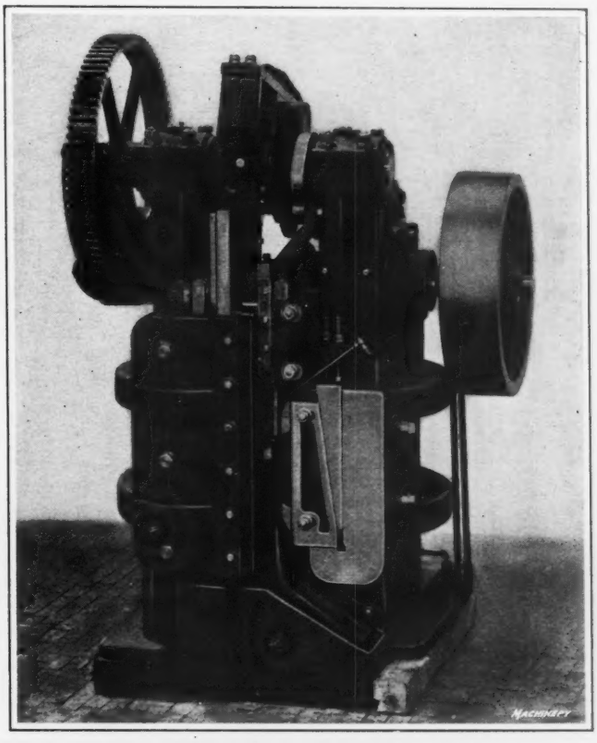


Fig. 17. Vertical Type of Thread-rolling Machine

[1] Associate Editor of MACHINERY.

die is cylindrical, forming a complete circle, whereas the other die is the segment of a circle. The segment-shaped die remains stationary. The part upon which a thread is being rolled passes between the revolving die and the fixed die. The adjustment of the distance between the two dies for securing diameter variations is regulated by means of the handwheels shown. The segment-shaped die is carried by a heavy casting that is eccentric with the shaft. By loosening one of the handwheels and tightening the other, the segmental die is advanced toward or withdrawn from the circular die. The bolt or other part to be threaded is placed in a holder and the operator, by moving a handle, moves the work forward to a point where it is caught between the dies. As soon as the thread-rolling operation begins, the carriage or holder drops back into the feeding position. There are four opportunities for feeding a blank between the dies for each revolution.

A number of advantages are claimed for the rotary type of machine. In the first place, the bolt or rod is fed into the machine while in a horizontal position, so that long rods such as are required for car trusses, bridges, etc., can be threaded with this machine. Other advantages claimed by the manufacturer are as follows: The massive compact construction adapts the machine for rolling larger sizes than has generally been considered possible heretofore. The machine is exceptionally durable because it has a rotary motion constantly in one direction, and for that reason runs much easier and will last longer than a machine having a reciprocating motion. The circular dies are more durable than straight or flat dies because when a bolt is rolled between two flat dies the rolling process always begins at the same point, but with circular dies the bolt enters and the rolling begins at different points; consequently, the breaking-down process or the beginning of the thread-rolling operation is not confined to one particular place on the dies, the result being that the wear is general and uniform over the entire die surface. A further advantage is claimed in regard to the speed of the machine, the contention being that there are four chances in each revolution for feeding a blank, so that the machine does not need to run nearly as fast as when there is but one opportunity to feed a blank for each revolution. At the rear of the main spindle of this rotary machine there are two spiral springs and means for putting them in tension. This is regarded as an important feature, because it keeps the round die in pitch with the segmental die and at the same time provides a certain amount of elasticity for the shaft.

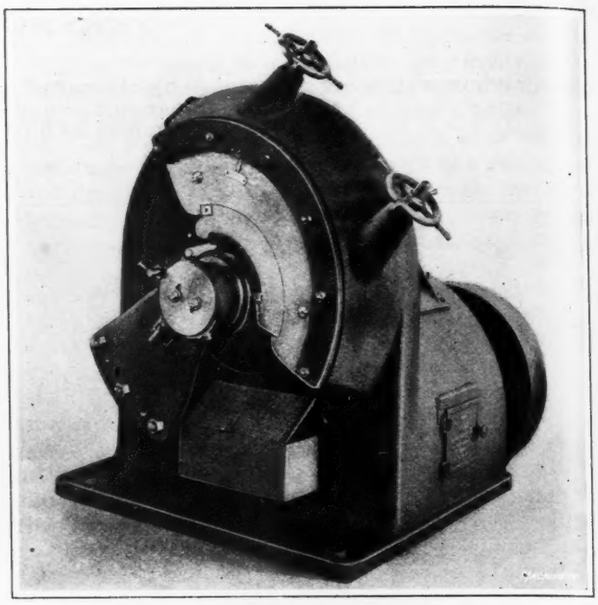


Fig. 19. Rotary Type of Thread-rolling Machine

Sizes of Screw Threads for which Rolling Process is Adapted

Thread-rolling machines are especially adapted for small and medium sized screws, although some machines are capable of rolling fairly large threads. The machines listed by several different manufacturers have nominal rated capacities for screw thread diameters varying from 1/16 inch up to 2 inches. These rated capacities do not represent the maximum diameters for which the machines can be used. For instance, a 1-inch machine is sometimes used for rolling 1¼-inch diameters or even larger sizes. The rated capacity represents what manufacturers believe to be the largest size of thread for which the machine should be used if the best grade of work is desired. The maximum diameter may depend upon the depth of the dies used. For example, if a machine has a rated capacity of ½ inch, this applies to dies of standard depth, but if the maximum-depth dies are used, naturally the largest diameter that can be rolled is diminished accordingly. The machines shown in Figs. 4 and 5 have a rated capacity of ½ inch each. Fig. 7 shows a ⅜-inch size, and Fig. 11 a ¼-inch size. The vertical machine illustrated in Fig. 17 has a rated capacity of 1 inch. This same design is also made in 1½- and 2-inch sizes. The rotary machine shown in Fig. 19 is made in ½-, 1-, and 2-inch sizes.

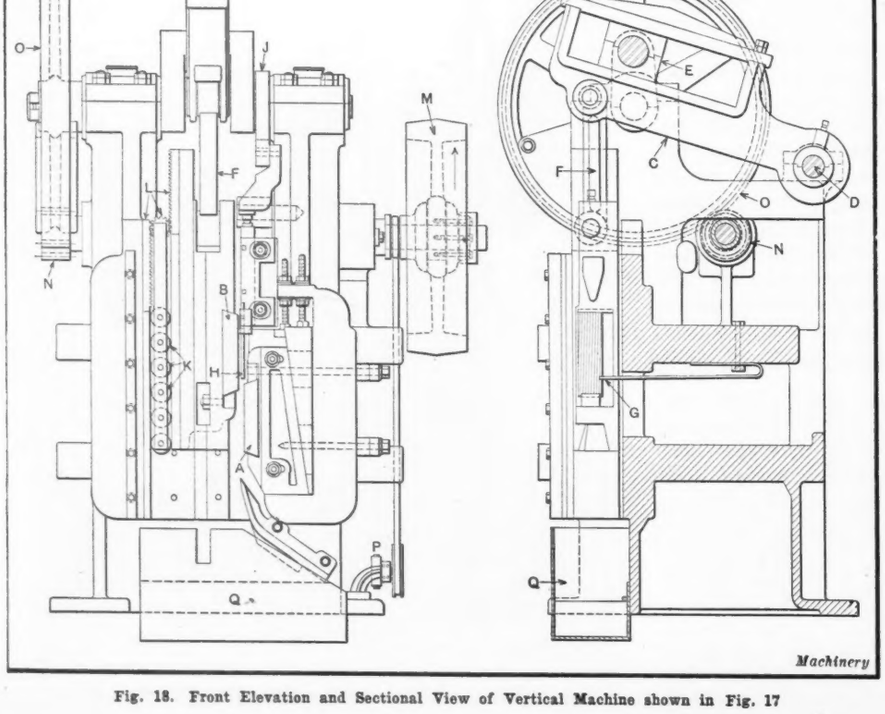


Fig. 18. Front Elevation and Sectional View of Vertical Machine shown in Fig. 17

An interesting type of thread-rolling machine, made by the Waterbury Farrel Foundry & Machine Co. for rolling threads on very small blanks having short shanks is illustrated in Fig. 22. The rated capacity of this machine is 1/16 inch. The important feature of the design is that the die faces are located at right angles to the chute of the automatic feed mechanism, so that the blanks enter between the dies at the lower end without changing from the inclined position in which they lie in the feed chute to a vertical position. With the ordinary arrangement, it is necessary for the blanks to assume a vertical position after leaving the feed chute, because the die faces are vertical instead of being inclined. By locating the dies in the inclined position, short and very small blanks may be fed automati-

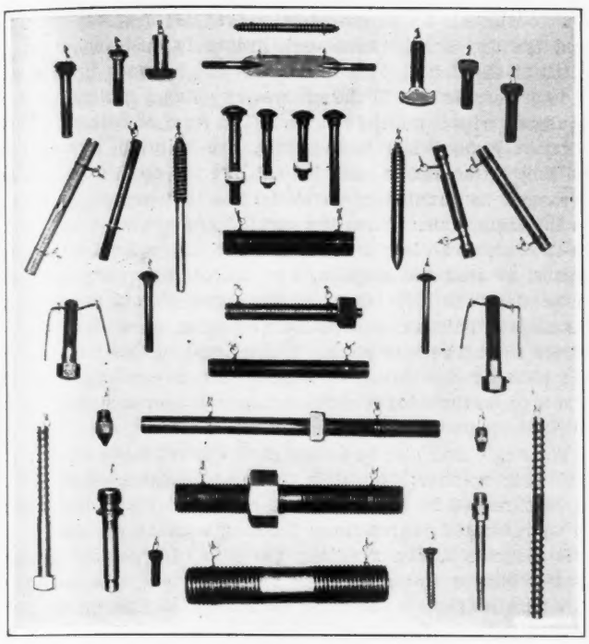


Fig. 20. Miscellaneous Examples of Rolled Screw Threads

cally, and it is not necessary to use a separator or cut-off blade at the foot of the chute, thus simplifying the construction. The pick-up blade in the hopper is provided with a groove or channel along its top instead of a slot for handling the short blanks.

Time Required for Rolling Screw Threads

The time required for rolling screw threads, or the rate of production, varies greatly for machines of different sizes. For instance, the machine shown in Fig. 22, which has a rated capacity of 1/16 inch, is capable of threading screws at the rate of 125 per minute, whereas a 1-inch machine of the same make will roll threads on about 30 pieces per minute. In a general way, these figures represent approximately the maximum and minimum rates of production for thread-rolling machines, the rate of production increasing as the size of the machine decreases. For instance, a ¼-inch machine may roll 70 or 80 screw threads per minute; a ½-inch machine, 45 or 50 per minute; and a ¾-inch machine, about 35 per minute. A comparison of these figures with the rates of production attained by other methods of forming screw threads will indicate the superiority of the thread-rolling machine for work within its range.

Advantages and Range of Thread-rolling Process

The principal advantage of the thread-rolling process is that it is the most rapid and economical method of forming screw threads, assuming that the work is suitable for a thread-rolling machine. Thread-rolling machines are used extensively for threading machine screws and various forms of special screws, track bolts and numerous other bolts, wood screws, lag screws, slender wires in a great variety of lengths and sizes requiring long or short threads and, in general, almost all small and medium-sized screws and bolts which are required in quantities large enough to warrant the use of a thread-rolling machine. Aside from the speed or efficiency of the thread-rolling process, one of the important advantages claimed for rolled screw threads is their strength as compared with threads formed by cutting. Extensive experiments conducted at one of the leading universities showed that the average rolled thread that was tested had an elastic limit 13 per cent higher than the elastic limit of a cut thread of corresponding size and material. The following explanation of the comparative effects of the rolling and cutting processes on the elastic limit and ultimate tensile strength of screw threads is given by the E. J. Manville Machine Co.

> In rolled or drawn round stock, the fiber or grain of the steel is usually parallel with its axis, its weakest section being at the center of the rod. The outside section of cold-rolled or drawn steel acts as a cover for the inner fibers and preserves the strain developed during the process of drawing or rolling to size. To cut into this wall or outside covering it is apparent that the strain within is somewhat released by cutting the threads, which tends to sever the fibers, and therefore the threaded part of a piece of drawn or rolled steel is of lower tensile strength than the unthreaded portion. In rolling threads on the same material, the blank is subjected to very severe treatment in the operation of cold-forging, which produces a weaving or crimping of the fibers within, thus adding strength and toughness to the material. It is therefore evident in a comparative test of two threaded pieces of the same size and material that the rolled thread blank is invariably of higher tensile strength than the cut thread.

Another advantage of the rolling process which may be of considerable importance in some cases is that no stock is wasted as when a thread is cut, because a blank smaller in diameter than the required screw thread is used when the thread is formed by rolling. The surface of a rolled thread is also harder than the surface of one which is cut, especially if the outer part of the stock has a scale which is rolled into the thread, thus making the surface harder and better able to withstand wear.

A general idea of the range of work which can be threaded to advantage by the rolling process is indicated in Figs. 20 and 21, which show a variety of samples of different shapes, lengths, and diameters. These views illustrate small watch and clock screws, machine screws of various sizes, wood screws, lag screws, studs of small and large sizes, and examples of special work. While thread-rolling machines are designed primarily for producing screw threads, they may be used to advantage in some cases for knurling, lettering, marking, grooving, and even for such operations as forming the teeth of small pinions. When these special operations are performed, the machine must, of course, be equipped with suitable dies. While thread-rolling machines are used principally for threading the ordinary commercial quality of screws,

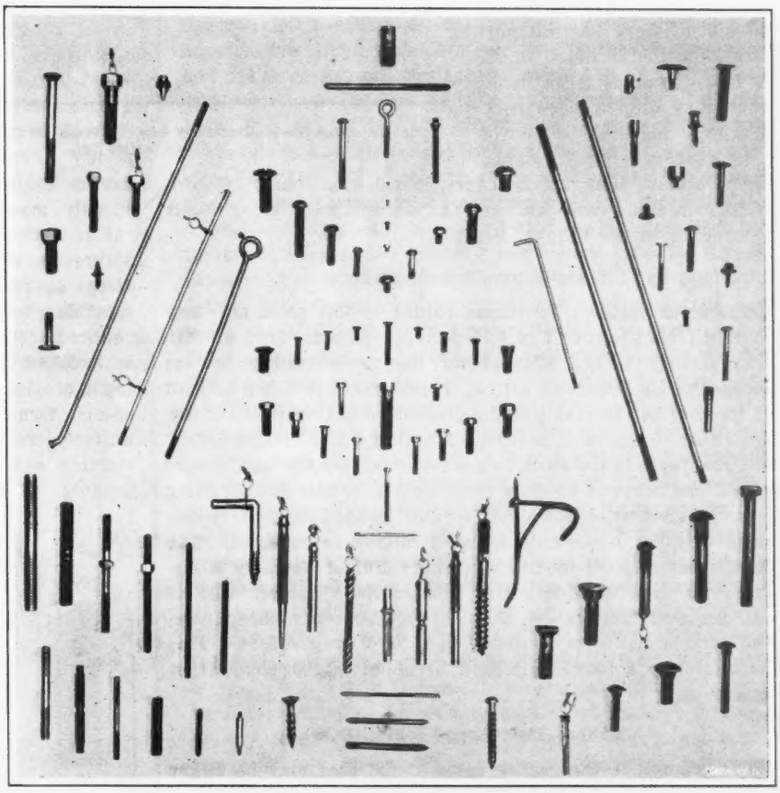


Fig. 21. Other Examples of Rolled Screw Threads

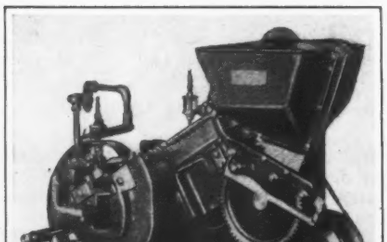


Fig. 22. Machine of Reciprocating Type designed for Very Small Work

bolts, studs, etc., accurate screw threads may be produced by the rolling process, which has even been employed for making screws used for micrometers.

Blanks for Machine Screws

When the threads of machine screws are to extend close to the head as illustrated at *A*, Fig. 24, the screw blank *B* is simply made to whatever diameter will enable a thread of the required size to be produced by the rolling process. If the body of the machine screw is to be threaded only part way, which is the usual practice, the finished screw will appear as illustrated at *C*, provided the form of blank shown at *B* is used. The thread in this case is larger in diameter than the unthreaded body of the screw simply because the upper section of a rolled thread is formed by forcing the metal above the original surface of the blank as explained previously. While the form of screw shown at *C* may be used for many purposes, it is objectionable for some classes of work, and in such cases it is necessary to make the body of the screw full size between the head and the threaded portion. The form of blank shown at *D* may be used to secure a body having the same outside diameter as the screw thread. A modification of blank *D* is shown at *E* and the threaded screw at *F*. In this case there is simply a short bearing surface beneath the head, which is full size or as large in diameter as the threaded part. While a machine screw of this kind is inferior to the form obtained with blank *D* for general use, it may be satisfactory in some cases and has the advantage of being easier to produce in the header.

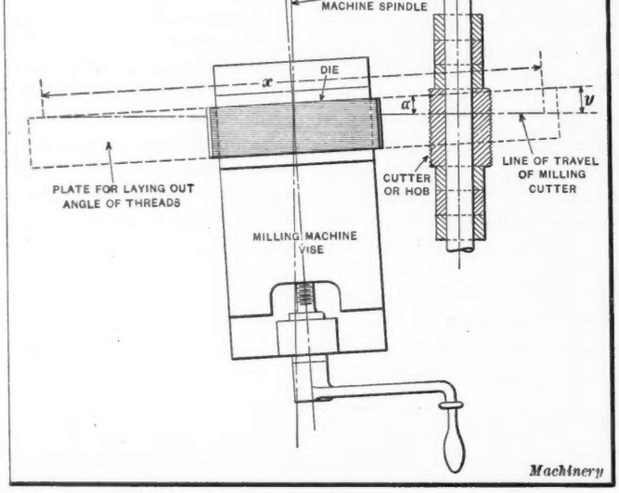


Fig. 23. Plan View illustrating how Teeth of Flat Thread-rolling Dies are milled

Stock for Thread Rolling

The stock suitable for thread rolling is soft steel, and may contain from about 0.07 to 0.12 per cent carbon. Iron of ordinary quality is not adapted for the thread-rolling process because of its fibrous structure, which makes it likely to split or fracture as the result of the pressure due to thread rolling. According to the E. J. Manville Machine Co., a "liquor-finish" soft steel wire is the stock to use for obtaining the best results with a minimum of wear on both the header and thread-rolling dies. A good grade of annealed and cleaned wire is recommended if the liquor-finished wire cannot be obtained. The stock recommended by the Waterbury Farrel Foundry & Machine Co. is of the following composition: carbon, 0.08 to 0.12 per cent; manganese, 0.35 to 0.45 per cent; phosphorus, 0.03 to 0.04 per cent; sulphur, 0.03 to 0.04 per cent. This material has a tensile strength of about 56,000 pounds per square inch.

Making Flat Thread-rolling Dies

The grooves in the rolling faces of flat dies may be either planed or milled. A simple method is to plane one groove at a time in a shaper. The tool should be shaped on the cutting end to conform to the cross-sectional shape of groove required, and the distance between each groove is made equal to the pitch of the thread. While the dies can be made in this way, it is preferable to mill the grooves by using a milling machine equipped with a multiple cutter. The form of cutter or "hob" commonly used has teeth which are relieved like a form milling cutter and are not helical like the teeth of a tap, but arranged in annular or parallel rows that are perpendicular to the cutter axis. When the parallel grooves are being milled in the face of a die, the latter must be inclined relative to the cutter, so that the angle *a*, Fig. 23, of the groove will correspond to the helix angle of the screw thread at the pitch diameter. This angle depends, of course, upon the diameter of the thread and its pitch. The tangent of this angle equals the pitch of the thread divided by the circumference of the blank to be threaded which corresponds approximately to the pitch circumference of the screw.

The angle may also be determined without calculation in the following manner: Multiply the circumference of the blank to be threaded by any number that will give a product equal to approximately three times the length of the die and lay off this distance *x*, Fig. 23, along the edge of a parallel strip or plate which is clamped in the machine vise. The outline of this parallel strip is indicated by the dotted lines in the illustration. The pitch of the thread is next multiplied by the number previously used to obtain dimension *x*, and a dimension *y* equal to the product is laid off at right angles to the parallel strip. A diagonal line connecting the points located in this way will represent the angle *a* to which the milling machine vise should be set. By traversing the diagonal line past the sharp end of a pointer clamped to the cutter-arbor, the angular adjustment may easily be made. The reason for increasing dimensions *x* and *y* as previously explained is to reduce by one-third any error of the angle. If the die is wider than the cutter, the entire face of the die may be milled by simply taking two cuts across it. When the die is milled in this way, it is, of course, essential after taking one cut across the die face to match accurately the milling cutter with the grooves previously machined.

The teeth of the dies used for rolling U. S. standard threads, V-threads, or Whitworth threads have a uniform cross-sectional shape from one end of the die to the other, with the possible exception of a short length near the ends which is relieved. This relief is provided at the ends so that the work will roll off the die without being marked by the corner. The teeth of dies intended for rolling square threads or those of special form, such as are found on large screws, are not of uniform cross-sectional shape, but are made V-shaped at the starting end so that the formation of the thread groove is gradual. If dies for rolling threads of the classes referred to

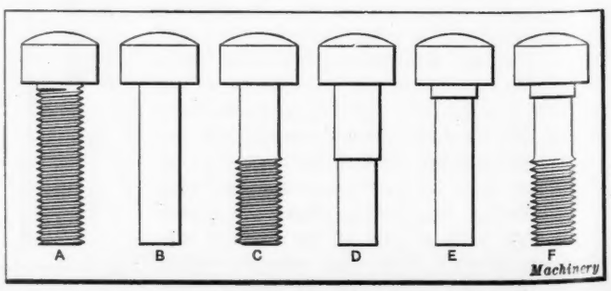


Fig. 24. Three Methods of making Blanks for Machine Screws

were made with teeth of uniform section throughout their length, the flat tops of the teeth would tend to compress the metal inward in a radial direction, instead of displacing it to form a thread, and the blank would be elongated in rolling.

The accuracy of a rolled thread depends largely upon the accuracy of the die and the cross-sectional shape of its teeth. The included angle of the teeth is one of the essential points. This angle should be somewhat less than the included angle of the thread to be rolled. For instance, dies for rolling U. S. standard threads should have teeth with an included angle of about 58½ degrees instead of 60 degrees, in order to produce a 60-degree rolled thread. This reduced angle is necessary on account of the elasticity in the stock, the effect of which is to cause the lower part of a rolled thread to spring back slightly after leaving the die, thus increasing the angle so that it is 1 or 1½ degree larger than the angle of the die teeth.

Thread Rolling in Screw Machine

The circular threading roll or disk that is used when threads are rolled in an automatic screw machine or turret lathe has a thread on its edge or periphery which corresponds in shape and pitch with the thread to be rolled, and this roll is forced against the screw blank while the latter is revolving. Fig. 25 illustrates how a circular roll may be applied. The unthreaded blank is held in the machine chuck and revolves about its axis. In screw machine practice, the threading roll *A* is usually mounted in a holder attached to the cross-slide of the machine. The roll is mounted on a pin or bolt so that it is free to revolve when brought into contact with the rotating piece to be threaded. A thread is reproduced on the work when the roll is forced against it with sufficient pressure to leave an impression of the thread on the roll.

The roll may be presented to the work in either a tangential direction as illustrated at *C*, or radially as shown at *D*. A satisfactory thread may be rolled in either way. When the roll is applied as shown at *C*, it gradually comes into contact with the periphery of the work and completes the thread as it passes across the blank surface in the direction indicated by the arrow. When the roll is presented in this way, the threaded piece should be cut off from the bar of stock before the roll is returned to its starting position to prevent injury to the finished thread. This is done by simply mounting a cutting-off tool on the cross-slide in such a position that it severs the finished piece after the thread is rolled. The cam operating the cross-slide is arranged to move the roll inward quickly until it is nearly in contact with the surface of the blank; the cross-slide and roll are then given a slow feeding movement usually varying from about 0.002 to 0.004 inch per revolution of the work, while the roll is moving a distance x from the point of contact to the central position. The roll is then moved rapidly past the work in order to bring the cutting-off tool into position.

When the roll is in a radial position, as illustrated at *D*, it is simply forced against one side of the work until a complete thread is formed, the roll and work rotating together the same as two gears in mesh. Some roll-holders, instead of being held rigidly, are carried by a swinging arm which receives its motion from some form of cam. The exact method

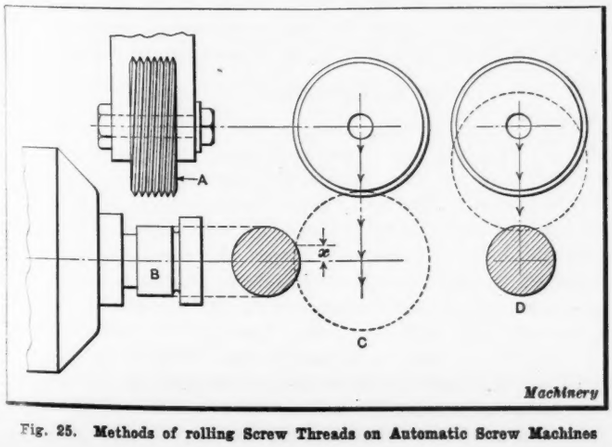


Fig. 25. Methods of rolling Screw Threads on Automatic Screw Machines

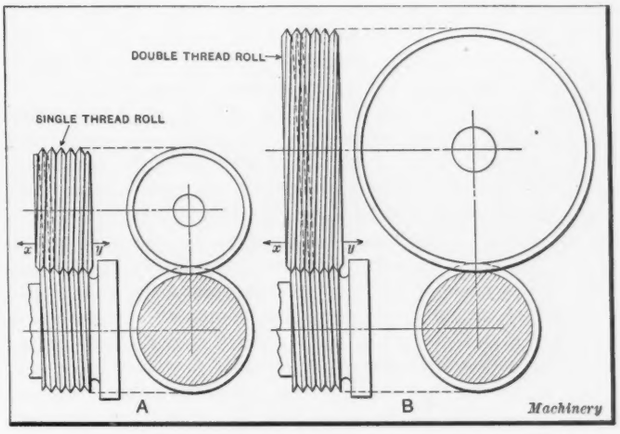


Fig. 26. (A) Threading Roll and Screw Thread of approximately the Same Diameter. (B) Threading Roll nearly Twice as Large in Diameter as Screw Thread

of applying the roll to the work and of holding it in position may depend to some extent upon the relation between the thread-rolling operation and other machining operations.

Diameter of Threading Roll

The diameter of the threading roll may be about the same as the diameter of the screw thread it is intended to roll, or some multiple of the screw thread diameter. If the thread to be rolled is larger in diameter than, say, ¾ inch, a roll may be used which is approximately equal to the diameter of the work, but if the required screw thread is much less than ¾ inch in diameter, the roll may be made twice as large or some multiple of the screw diameter. When the roll and the screw thread are about the same diameter, they are practically alike so far as pitch and diameter of the thread are concerned. For instance, the roll for a ¾-inch screw thread might also be ¾ inch minus a slight amount in order to obtain a better rolling action, as explained later. If the screw thread to be rolled were ½ inch in diameter, the roll might be two or three times as large.

Whatever the relation between the size of the screw thread and the roll, it is essential to use a roll having threads that mesh with or follow the threads on the work as the two revolve together. This means that the roll thread must have the same pitch as the screw thread and about the same helix angle. Now when the diameters of the threads on the roll and the work are practically duplicates, the roll for a ¾-inch single screw thread would also have a single thread as shown at *A*, Fig. 26. If the roll is twice as large as the screw, it cannot have a single thread because, for a given pitch, any increase of the roll diameter reduces the angle between the thread and a plane perpendicular to the axis; therefore, if the diameter of the roll is made twice as large as the screw thread, it is necessary to use a roll having a double thread as illustrated at *B*, instead of a single thread. The pitch of the double thread remains the same, but since the lead equals twice the pitch, the helix angle of the thread is the same as for a single thread of one-half the diameter. If a roll three times the size of the screw thread were used, it would require a triple thread, and so on.

If we assume that a roll is used having the same diameter as the thread after rolling, it will rotate at a slower rate than the work at the beginning of the rolling operation because the roll is larger than the unthreaded screw blank and is driven by the blank. As the roll sinks into the blank, its speed gradually increases until, under ideal conditions, the speed is practically the same as that of the thread being rolled. It has been found in practice that better results are obtained when a roll is used that is slightly smaller in diameter than the diameter of the screw thread to be rolled. For instance, if the work has a ¾-inch U. S. standard thread, a single-threaded roll used for this operation might have a diameter of, say, 0.660 inch instead of 0.750 inch. If a larger roll having a double thread were used, its diameter would equal $2 \times 0.660 = 1.32$ inch instead of 1.50 inch.

The reason for decreasing the diameter of the roll will be

more apparent by considering the action of the roll and screw thread when a thread is being formed. As previously mentioned, the roll rotates at a slower speed than the screw blank, especially when the rolling operation begins, because the outside diameter of the roll is in contact with the plain blank, which is about as large as the pitch diameter of the screw. As the rolling of the thread progresses, the roll speed might increase until it was practically the same as the work speed, but on account of frictional resistance between the roll and its holder, the natural tendency is for the roll to lag behind the screw thread. Now any retardation of the roll causes an increase of frictional resistance and the final result may be that the roll speed decreases to such an extent that it no longer meshes with the screw thread properly and, consequently, the thread is marred or spoiled.

The action between the roll and the screw thread will be more apparent by referring to Fig. 26. When the roll lags behind, the more rapidly revolving work, acting as a screw, forces the roll over against the side of the holder, as indicated by arrow x. The resulting increase of frictional resistance causes the roll to revolve still slower. On the contrary, if the roll is a little smaller in diameter than the work, so that it rotates faster, the roll tends to move in the opposite direction, as indicated by the arrow y. If this movement occurs and the roll presses against the side of the holder, thus increasing the frictional resistance, this tends to reduce the speed and cause the roll and work to rotate together properly; consequently, with the roll running a little faster than the screw, any difficulty from side thrust is cared for automatically because then the driven roll tends to move axially in a direction opposite to that in which the screw thread on the work would naturally force it.

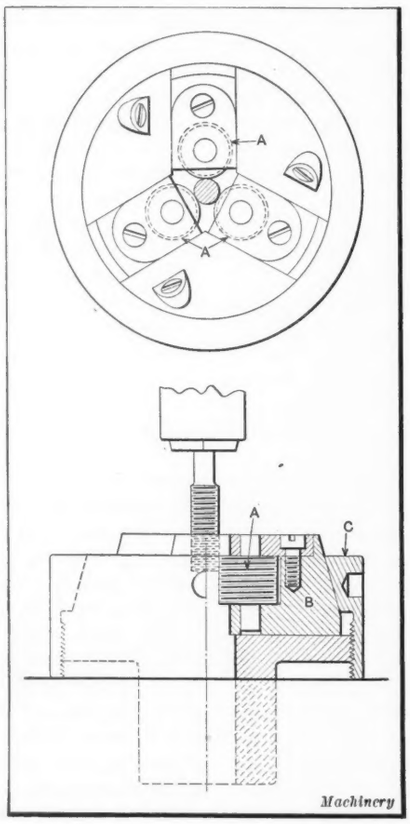


Fig. 27. Rolling Tool for finishing Threads on Taps

Calculating Threading Roll Diameter

The outside diameter of the threading roll may be determined by the following rule: Multiply the depth of a single thread (corresponding to the pitch of the thread to be rolled) by 1.25; subtract the product from the outside diameter of the required thread, and multiply the difference by the number of threads or "starts" on the thread roll. This rule is embodied in the following formula, in which R = outside diameter of roll; N = number of starts or threads on roll; S = outside diameter of finished screw thread; and D = depth of a single thread:

$$R = N(S - 1.25D) \qquad (1)$$

To illustrate the application of the rule and formula, suppose a roll is required for a ⅝-inch U. S. standard thread. Then $S = 0.625$ inch and $D = 0.059$ inch. $0.625 - 1.25 \times 0.059 = 0.5513$ inch, which would represent the diameter of the roll if it were made with a single thread. Such a roll, however, would be too small and the diameter would probably be doubled, which would make it necessary to use a roll having a double screw thread. In that case, diameter $R = 2 \times (0.625 - 1.25 \times 0.059) = 2 \times 0.5513 = 1.100$ inch, approximately.

The following method of determining the roll diameter has been used successfully by a prominent manufacturer of automatic screw machines. *Rule:* Determine the pitch diameter of the thread to be rolled and deduct from it one-sixth of the double depth of the thread; then use the constant thus obtained as a multiple for determining the pitch diameter of the thread roll. Ordinarily, the roll would be two, three, or four times the diameter of the screw thread and have either a double, triple, or quadruple thread in order to secure the proper thread helix angle. Expressing the preceding rule as a formula,

$$P = M\left(D - \frac{T}{6}\right) \qquad (2)$$

in which, P = pitch diameter of thread roll;
M = multiple selected with reference to approximate diameter of roll desired (this number also equals the number of threads on the roll);
D = pitch diameter of screw thread;
T = double depth of thread.

Kind of Thread on Roll

The thread or threads on the roll should be left-hand for rolling a right-hand thread, and *vice versa*, so that the thread on the roll and work will incline in the same direction at the point of contact. The roll should also be wide enough to overlap the section to be threaded, provided the latter is necked or turned down at the ends to provide a clearance space, which should be done if possible. The thread on the roll should be sharp on the top for rolling U. S. standard threads as well as V-threads. If the roll thread is made flat, the blunt edge will require too much pressure to force it into the metal and will not produce as smooth a thread. While a roll made in this way will not form a correct U. S. standard thread, the fact that the thread has a sharp bottom, instead of the standard flat form, may be of little importance as compared with the advantages of the rolling process. The bottom of the thread groove on the roll may also be left sharp or it may have a flat, some rolls being made one way and some the other. If the thread groove is sharp in the bottom, the roll is sunk only far enough into the blank to form a thread having a flat top. Some contend that it is preferable to have a flat at the bottom of the threading roll groove in order to roll down the top of the thread and thus obtain a smoother edge or surface.

The ends of the roll should be beveled to an angle of about 45 degrees so that the thread or threads will not chip or break out when rolling a thread. Incidentally, the threads on rolls are usually finished by lapping after hardening in order to make them smooth. As the roll is simply driven by frictional contact with the work, it is essential to reduce the frictional resistance of the roll-holder as far as possible. The pin upon which the roll revolves should be only slightly larger than is necessary to reduce the shearing strain when rolling a thread. For instance, a ½-inch hole in a thread roll 1 inch in diameter might cause considerable trouble owing to the frictional resistance, whereas, a hole ⅜ inch in diameter might prevent trouble resulting from lagging or retardation of the roll.

Finishing Tap Threads by Rolling

The rolling process has been applied to the manufacture of taps for finishing tap threads, although the method to be described has not been satisfactory for all classes of work. The tap thread is first cut to approximately the required shape and size, and then the tap is passed between rollers which compress the metal and give the thread the correct form. The advantage claimed for this finish-rolling process is that it increases the density and hardness of the thread, with the result that a rolled tap will resist wear considerably better than a tap which is finished by a cutting tool. Some contend that small taps having rolled threads are five times as durable as those with cut threads.

The tool used for rough-forming the tap threads prior to

rolling has an angle of 57 degrees for a U. S. standard thread and 53 degrees for a Whitworth thread, and the annular ridges on the rolls have an included angle of from 60½ to 61 degrees for a U. S. standard thread and from 55½ to 56 degrees for a Whitworth thread. This increase in the angle of the roll is necessary in order to obtain a 60-degree angle on the tap, when the roughly formed thread is 2 or 3 degrees less than the standard. The object of cutting the thread to this decreased angle is to obtain an increasing degree of compression of the metal from the root to the top of the thread. Owing to the elasticity of the stock, the thread roll has a greater angle than the standard thread angle to compensate for the slight expansion or springing back of the metal after the rolling pressure is released.

The outside of the rough-threaded blank is somewhat under the standard size, the amount depending upon the pitch of the thread and the diameter of the tap. For instance, a 1/2-inch tap would be rolled from a blank having an outside diameter of 0.488 inch. A roughly formed Whitworth thread has a round root, but the crest or top of the thread is left flat. The crest is rounded to the standard radius by the finishing rolls.

Fig. 27 shows a design of thread-rolling tool that has been used in connection with tap manufacture. There are three rollers *A* located 120 degrees apart. The annular ridges on these rollers are perpendicular to the axis, and not helical like a thread. The rollers are mounted in the same plane, but the ridges on successive rollers are located one-third the pitch in advance, so that they will engage the thread to be rolled. The tool illustrated is provided with adjustable blocks *B* in which the rollers are mounted. These blocks are tapering and are backed up by the taper ring *C*, which provides means of adjusting the rolls radially. The blocks are held in position by binding screws inserted in the front face of the holder at an angle of 45 degrees.

When the rolls engage the point of the rough-threaded tap blank, they roll down the first threads slightly below the full diameter, because, when the entire surface of the rolls are in contact with the tap, there is some springing action and the tap diameter is somewhat larger as the result. When the taps are made in sets of three, the rolling process may be applied to "taper" and "plug" taps, but is not satisfactory for the "bottoming" tap, because of the taper rolling at the end. In the case of the taper and plug taps, however, the threads at the end are relieved at the top to such an extent that the slight taper caused by rolling is of no account.

* * *

EXCESSIVE LABOR TURNOVER

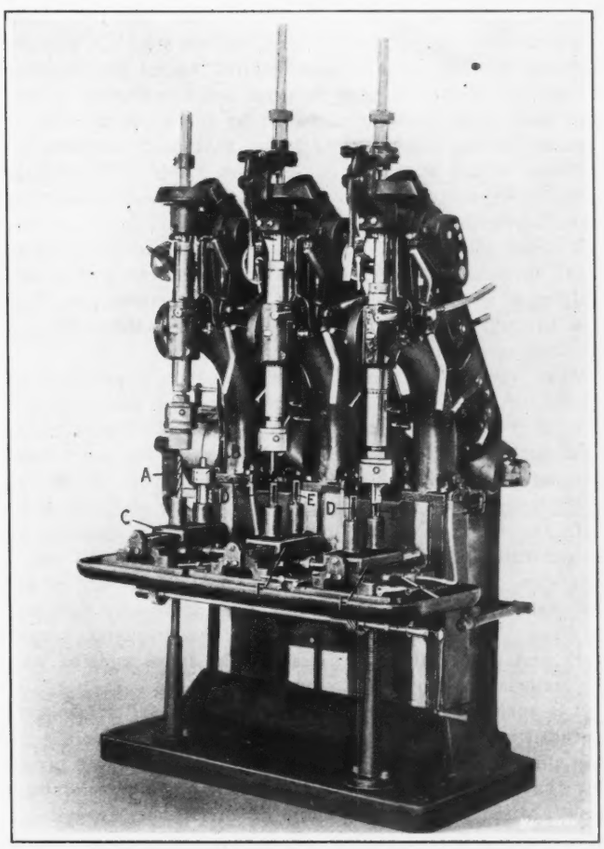
It has been estimated that of the 7,000,000 men composing the industrial labor force of the United States, one-half change their places of employment at least once each year. This constant changing annually costs our industries $140,000,000, if not many times this sum, for it costs from $30 to $200 to train a new man, depending on the nature of the work to be done and the industry, or an average of from 1.5 to 2.5 per cent of the pay roll. In addition, figures gathered from the iron and steel trades by the United States Department of Labor show that of 1000 employes with six months' experience 111.3 are injured while only 42.4 out of 1000 are injured of those having from three to five years' experience. Much money might be saved by eliminating the necessity of discharging labor during slack seasons. In Europe, good results have been obtained by using the quiet season in the home market for manufacturing for foreign trade; the changing seasons of the southern hemisphere bring orders to Europe just at the time when business becomes dull at home.

* * *

American manufacturers planning to enter the Central or South American markets should patent their articles and register their trademarks in each country that they desire to enter before beginning their sales campaign. As a convenience to such persons, the Bureau of Foreign and Domestic Commerce has prepared a list of attorneys in the various countries of Latin America who are qualified to attend to such matters.

DRILLING, FACING, AND TAPPING STUDS

Efficient results are being obtained in drilling and tapping a hole in steel studs and facing the surface around the tapped hole, through the use of a three-spindle 20-inch all-geared drilling machine built by the Barnes Drill Co., of Rockford, Ill., which is tooled up as shown in the accompanying illustration. Here it will be seen that advantage is taken of the inverted principle, the work being rotated in chucks mounted on the drilling machine spindle and fed down onto the top of inverted tools, so that the chips will be readily cleared from the work through the action of gravity. It will be seen that under the left-hand spindle there are a drill *A* and facing tool *B*, which are brought successively into position under the spindle by means of a sliding fixture *C*, which is provided with limit stops to locate either tool. A positive depth stop on the spindle controls the facing operation. The work is fed down onto the



Barnes All-geared Drilling Machine tooled up for drilling, facing, and tapping Studs

tool by the regular feed on the machine, and after the drilling and facing operations have been completed, the work is transferred to either of the other two spindles, where it is held in the three-jaw chuck with which each of these spindles is provided. Under each of these spindles there are a roughing tap *D* and a finishing tap *E* carried on a sliding fixture *F*, so that the tapping operation may be completed by first roughing and then finishing the thread, the lead being governed by a positive leading device on the spindle. With an outfit of this kind, the operator has plenty to do to keep all of the spindles on the machine constantly employed. E. K. H.

* * *

The following definition of an eccentric, applied by a lawyer arguing an engineering case before the court, may not be mathematically correct, but it is a fairly good description. The lawyer, having repeatedly referred to an eccentric, the judge at length asked him what an eccentric was; he said he was familiar with the term as applied to individuals, but not as applied to a part of a machine. The lawyer defined it as follows: "An eccentric," he said, "is a circular disk whose center is not in the middle."

STEEL TESTS USED BY WORKMEN[1]

Among the various ways of judging the quality of steel, the most common are: trade or quality stencil marks, labels pasted on the bars, bars painted different colors, general shape of the material, appearance of surface, heft or weight, ring or tone of metal when dropped, feeling, intuition, smell, fracture test, fire and water test, service test, and spark test.

The first two are the most dependable methods, except that if the steel is kept in a damp place, the labels will drop off in the course of time due to rust. The third method is dependable if a general scheme of colors is used for the different brands of steel and the system is intelligently applied. There is, however, in many factories extreme carelessness and indifference in the painting of valuable stock; in one factory seven grades of steel were painted one color.

Many workmen select steel by its general shape; for instance, a hexagon section will represent screw stock and an octagon section will indicate cold chisel steel. But this method of selecting should not be tolerated, because steel can be manufactured into any form or shape desired, except stellite, which is cast into form. It may surprise some engineers to learn that many tool steels are selected by the appearance of the surface. If the bars are smooth and have sharp corners, it is evidence to the workmen of first-class steel. Without other evidence, expensive labor is put upon the tool and usually only when hardening is the mistake discovered. Smooth surfaces and sharp corners indicate work at low temperatures, while rough surfaces and round corners are caused by an iron oxide scale when the metal is laid down at high temperature; therefore, the appearance of the surface does not indicate the quality or composition of the metal.

Many workmen, not satisfied by the shape, appearance and weight, drop the metal on a hard floor or a heavy piece of iron; if the ring is a sharp tone, the metal is thought to be a good quality of steel. The finer the grain, the more homogeneous the structure, and the harder the metal, the sharper is the tone. These qualities are developed by elements in the metal, by working, and by heat-treating at a moderately low temperature. On the other hand, wrought iron will emit a dull tone, owing to the presence of about 2 per cent of slag and the usual methods of working such metal at a high temperature. This method is not reliable or dependable, because work and heat-treatment will affect the tones emitted when the material is struck or dropped.

It is surprising how many expert toolmen will select metal by intuition; and because of their opinion they work the tool into shape regardless of any indication in its cutting properties that the metal may be undesirable. Their mistake is usually discovered when attempting to harden the metal or when putting it into service. It is said that in the southern part of the state a man nicks a bar of stock with a cold chisel, breaks it in two, and immediately smells the fracture, claiming that a good quality of steel smells like ammonia. There is no ammonia in steel. Many of the tests used by workmen are just as reliable.

The fracture test does not represent the true quality of metal, but rather indicates the last heating operation to which the metal was subjected. A fracture that has a coarse granular appearance may not mean that the material is of inferior quality, but that it was laid down at a high heat and the crystals retained the size corresponding to that heat. There are exceptions to this rule, however, for many of the elements in alloy steels prevent or retard crystallization at high temperature. High-speed steel shows an unusually fine grain after being heated to 2250 degrees F.; on the other hand, carbon tool steel heated to its critical temperature and immediately quenched shows a fine silky structure, and it is doubtful if the average mechanic is able to distinguish these metals when they are placed together for comparison. If a small piece of carbon tool steel is heated to just above its critical temperature, about 1450 degrees F., known as a dark cherry red, and immediately quenched in water, it will be hard enough to resist a sharp file; and when fractured, it should show a fine silky structure. If a low or inferior grade of carbon steel is treated in this manner, the surface may be hard enough to resist a file but the fracture will not show a fine structure.

Many workmen as well as the experimental engineer select available material at hand without any determination as to quality, and then put expensive labor upon the part or tool. When finished, it will be tried out in service, and if it fails, something else is tried. Such failures are usually found in the scrap heap. The service test, however, has its advantages if the engineer has a knowledge of the material so tested. This information is invaluable, as it is the combination of successes and failures that gives the empirical knowledge that completes the perfect understanding of theory. A record of the life work of a piece of steel and accurate data are the most powerful tools that an engineer has. Therefore, the scrap heap of failures is the most instructive place about a plant.

The spark method is based on the action of the oxygen of the air on the combustible element present in iron and in many of the alloying elements contained in the different steels, which act explosively when heated to a temperature necessary for combustion. To produce bright sparks as the result of heating finely divided particles of metal, the heat must be intense enough to cause chemical combustion between the oxygen of the air and the particles of metal.

[1]Extract from an address by John F. Keller, of Purdue University, Ind., delivered in March, 1917 before the Steel Treating Research Society of Detroit, Mich.

* * *

DEFINITION OF POUNDAL

The expression "poundal" is sometimes used in connection with calculations in mechanics. A good many mechanical handbooks, however, do not define it, because of its limited use. A poundal is a unit of force, and is defined as that force which, acting on a mass of one pound for one second, produces a velocity of one foot per second. A foot-poundal is a unit of energy and is equal to the energy resulting when a force of one poundal acts through a distance of one foot. In order to reduce foot-poundals to foot-pounds, multiply the number of foot-poundals by 0.03108. Dividing the number of foot-poundals by 32.16 (acceleration due to gravity) will also give foot-pounds.

If the well-known formula for energy

$$E = \frac{mv^2}{2} \text{ is written } E = 0.01554mv^2$$

E will be expressed in foot-pounds if m is expressed in pounds and v in feet per second.

When the formula is written in the customary form

$$E = \frac{mv^2}{2}$$

E is in foot-poundals when m is in pounds and v in feet per second. (If in this formula m is in kilograms and v in meters per second, then E will be in joules.)

For metric units the formula may be written as follows:

$$E = 0.00051mv^2$$

in which case, E is expressed in gram-centimeters; m, in grams; and v, in centimeters per second.

If the formula is written

$$E = 0.051mv^2$$

E is in kilogram-meters; m, in kilograms; and v, in meters per second.

These formulas are based upon the standard value of gravity. In the rare cases where a variation in gravity must be considered, the fundamental formula giving E in foot-poundals (or in the absolute system of measurement in joules) must be used.

* * *

The United States now leads the world in the production of ferro-manganese. During the last fiscal year it imported 656,088 gross tons of manganese ore, more than Great Britain ever imported, and had a domestic production of around 80,000 tons. This means a production of 270,000 tons of ferro-manganese in the current year. While it is estimated that 336,000 tons are needed, the shortage can be made up by importations and by a more efficient use of spiegeleisen.

SOLENOIDS AND ELECTROMAGNETS

PRINCIPLES, PROPORTIONS, AND APPLICATIONS IN VARIOUS KINDS OF MACHINES

BY CHARLES A. CLARK [1]

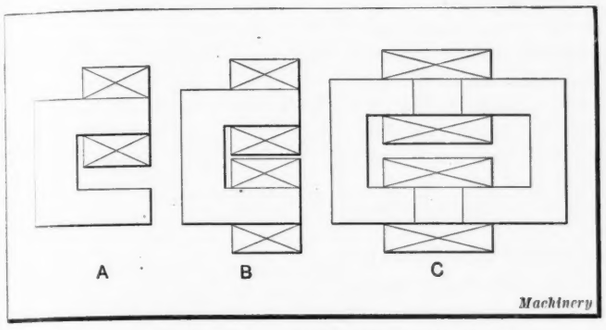


Fig. 1. Simple Types of Electromagnets and Solenoids

SOLENOIDS and electromagnets have been used for years in connection with various kinds of machinery for releasing brakes, actuating clutches, operating valves, shifting gears, controlling the operation of motors, etc. Electromagnets may be of the horseshoe type with one coil, shown at *A*, Fig. 1, or of the horseshoe type with two coils, as shown at *B*. Solenoids, also, are magnets in a general sense and to all intents and purposes. One type has a yoke with two projecting pole pieces that extend into the upper ends of the coils, as shown at *C*, and a pair of plungers attached to a yoke-shaped piece that enters into the coil when it is electrified. This coil is generally termed the armature. The second type, shown in section in Fig. 2, has no projecting pole pieces extending into the upper ends of the coils. Here *A* is the fiber coil or spool end; *B*, the coil set-screw; *C*, the cap; *D*, the solenoid cover; *E*, the ventilating ducts; *F*, the coil tube or spool; *G*, the coil; *H*, the air passage; *L*, the solenoid case; *M*, the lead bushing; *N*, the holes for the pivot; and *O*, the slot for the part to be moved.

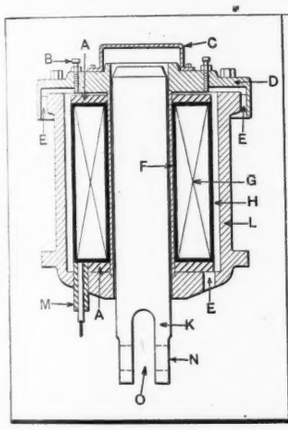


Fig. 2. Section through Solenoid

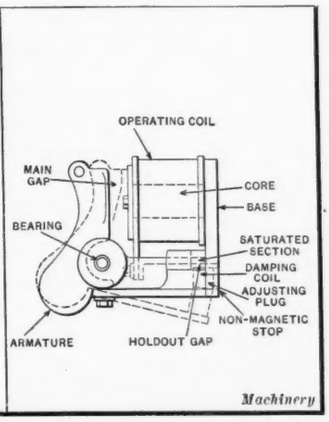


Fig. 3. Contactor Magnet Frame

Electromagnets are used generally where there is a relatively small movement of the armature and a small air gap, such as for operating telephones, electric horns, bells, controller mechanism, automatic switches, etc. They are also used extensively on switchboards of both direct and alternating circuits, and are seen in operation in almost every manufacturing plant. A type commonly used is shown in Fig. 3.

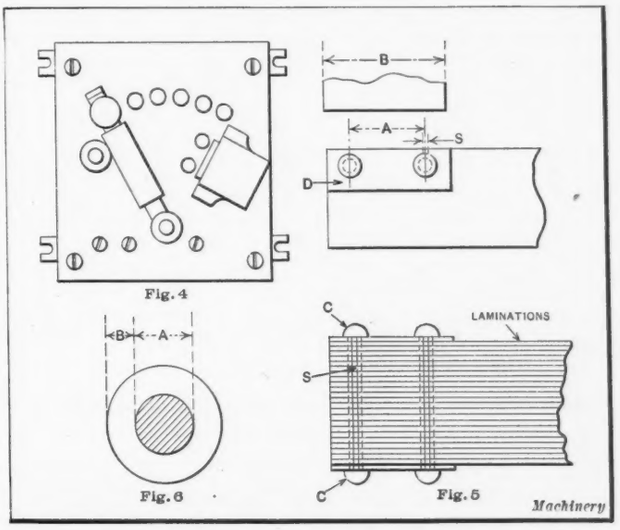


Fig. 4. Starting Rheostat for Direct-current Motors. Fig. 5. Pole Shader. Fig. 6. Section through Magnet Winder

The rheostat for starting direct-current motors, shown in Fig. 4, uses a magnet for holding the switch arm in the running position while the current is on, but when the current is cut off the magnet releases the arm, which is forced back to its off position by a suitable spring. The motor cannot be operated again until the rheostat handle is moved into the running position and held there by the attraction of the magnet. Direct-current magnets have soft iron cores, and their armatures do not require any pole-shading devices like the alternating-current magnets.

The pole shader in an alternating-current magnet is a short-circuiting ring embedded in the pole face to retard the time-phase relation of the magnetic flux within the ring so that

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TABLE 1. MAGNETIC QUALITY OF IRON AND STEEL

Magnetic Density per		Sheet Iron, Annealed					Cast Steel, Unannealed					Wrought-iron Forgings					Gray Cast Iron				
		Magnetizing Force per		Ampere-turns per			Magnetizing Force per		Ampere-turns per			Magnetizing Force per		Ampere-turns per			Magnetizing Force per		Ampere-turns per		
Square Centimeter	Square Inch	Square Centimeter	Square Inch	Centimeter Length	Inch Length	Permeability	Square Centimeter	Square Inch	Centimeter Length	Inch Length	Permeability	Square Centimeter	Square Inch	Centimeter Length	Inch Length	Permeability	Square Centimeter	Square Inch	Centimeter Length	Inch Length	Permeability
1,550	10,000	2.480	16	1.973	5.011	625.0	2.790	18	2.219	5.638	555.5	1.860	12	1.480	3.258	833.3	9.92	64	7.89	20.04	156.3
3,100	20,000	3.565	23	2.836	7.204	869.6	4.340	28	3.452	8.770	714.3	2.325	15	1.850	4.698	1333.3	16.28	105	12.95	32.89	190.5
4,650	30,000	4.340	28	3.452	8.770	1071.4	5.425	35	4.312	10.960	857.1	2.790	18	2.219	5.638	1595.7	25.42	164	20.22	51.36	182.9
6,200	40,000	5.115	33	4.069	10.340	1212.1	6.665	43	5.302	13.470	930.2	3.565	23	2.836	7.204	1739.1	40.61	262	32.30	82.06	152.9
7,750	50,000	6.510	42	5.179	13.150	1190.4	8.370	54	6.658	16.910	925.9	4.650	30	3.699	9.396	1666.6	66.65	430	53.02	139.68	116.3
9,300	60,000	8.215	53	6.535	16.600	1132.0	11.160	72	8.878	22.550	833.3	6.820	44	5.425	13.780	1363.6	112.29	718	88.53	229.49	83.6
10,075	65,000																159.65	1030	127.00	322.60	63.1
10,850	70,000	10.540	68	8.384	21.300	1029.4	15.350	99	10.850	31.010	707.1	10.080	65	8.015	20.360	1076.9					
12,400	80,000	14.570	94	11.590	29.440	851.0	22.630	146	18.000	45.730	547.3	16.120	104	12.820	32.570	769.2					
13,950	90,000	21.390	138	17.020	43.220	652.2	34.880	225	27.740	70.470	400.0	31.000	200	24.660	62.640	450.0					
15,500	100,000	33.170	214	26.390	67.020	467.3	58.130	375	46.240	117.450	266.6	66.650	630	53.020	139.680	232.6					
16,275	105,000											97.650	630	77.680	197.320	166.6					
17,050	110,000	57.970	374	46.110	117.140	294.1	113.150	730	90.010	228.640	150.7	160.450	1035	127.620	324.160	106.3					
17,825	115,000						157.330	1015	125.150	317.900	113.3										
18,600	120,000	112.380	725	89.390	227.070	165.5															
19,375	125,000	166.630	1075	132.520	346.690	116.3															

Machinery

there is, at every instant, enough magnetism to hold the magnet closed, as shown in Fig. 5. The area of *A* is two-thirds the area *B* of the pole face. One-eighth-inch brass rivets are shown at *C;* at *D* are the end plates; and at *S* are slots or saw cuts.

One square inch of core surface with 100,000 lines per square inch saturation in an alternating-current magnet with an air gap of 1/8 inch will pull about 140 pounds. The pole face of an alternating-current magnet to have the same pull as a direct-current magnet must have twice the area. The area of the winding *B* of a magnet should be about 59 per cent of the area of the core *A*, as shown in Fig. 6.

Where the magnetic density is not great, it is safe to use cast iron for the cores of an alternating-current magnet, but

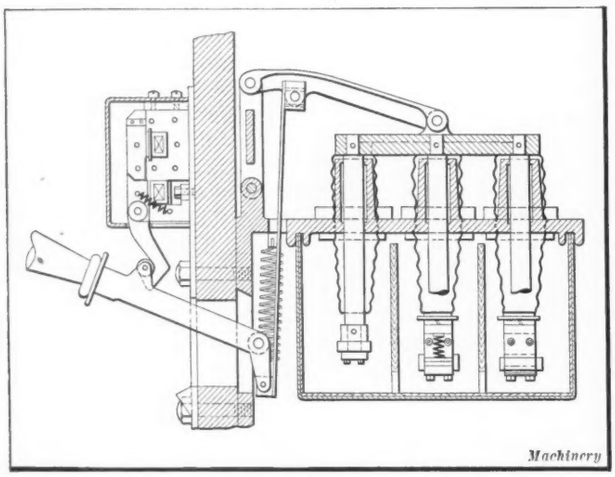


Fig. 7. Oil Switch with No-voltage Release Magnet

where the density is high, sheet-iron laminated cores should be used. In all magnets of sixty cycles, where the density is high, transformer iron should be employed. The magnetic density, the magnetizing force, ampere-turns per inch and per centimeter, and permeability of sheet iron, cast steel, wrought-iron forgings, and gray cast iron are given in Table 1.

Applications of Electromagnets

Fig. 7 shows the application of an alternating-current magnet in holding the handle of a 6600-volt, 200-ampere oil switch in the operating position. The coil is applied to the pole next to the pivot of the armature. There is a relatively small movement of the armature, and a pole shader is placed at the end of the armature. When the armature function is to hold the handle of the mechanism in the running position, both single- and double-coil magnets may be used. One of the many applications of double-coil magnets to pivoted armatures and disks is found in a loud-speaking telephone and in the electric horn.

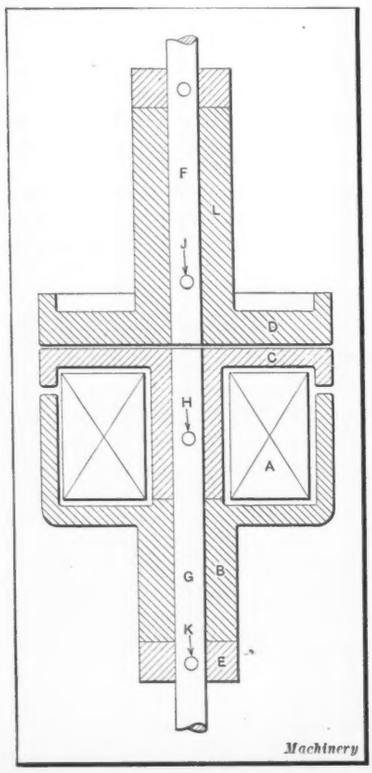


Fig. 8. Magnetic Clutch for Light Work

One of the many uses of the electric magnet in light machine work is shown in Fig. 8, in which a magnet coil is mounted in a fixed case *B*. The core *C* is fastened to a revolving shaft *G* by a pin *H*, and is held in its proper position by a collar *E* fastened to shaft *G* by a pin *K*. Directly opposite core *C* and separated from it by a very small air space is a plate *D* of the same area as the core, having a hub *L* that is pinned to the shaft *F*. The two shafts *G* and *F* are in line. Power is applied continuously to shaft *G*, so that, when it is desired to run shaft *F* with any mechanism, an electric current is applied to the fixed coil *A*, which magnetizes the revolving plate *C*, causing it to attract plate *D* and forcing the latter, with shaft *F*, etc., to revolve, although in reality there is no physical connection between them.

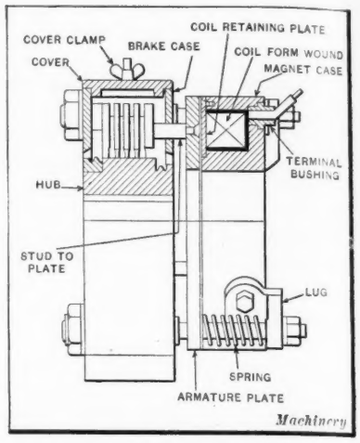


Fig. 9. Magnetic Disk Brake

Another of the uses of the electric magnet is in a magnetic disk brake. The one shown in Fig. 9 consists of a revolving hub carrying plates fastened to it. Below these plates are others connected to an armature plate through the containing case. The armature plates are held against the plates on the revolving hub by springs, one of which is shown, thus retarding and stopping the motion of the hub, but when the electric current is applied to the magnet coil, the armature plates are attracted to the coil and the friction plates are separated as long as the current is applied. These magnetic brakes are used with electrically driven machinery, such as hoists, cranes, ore and coal handling machinery. They are adapted for use

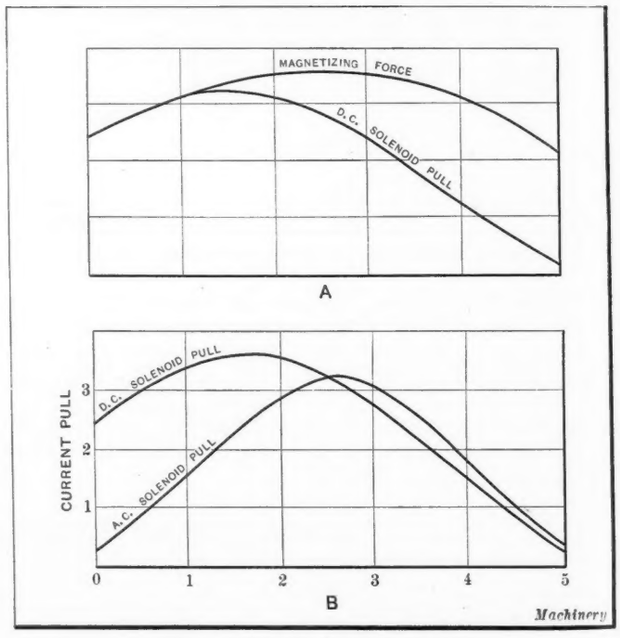


Fig. 10. Charts showing Solenoid Pulls

when frequent stops and removals are required and when the safety of the machinery depends on the reliability of the brake employed.

The Solenoid

As a magnet is a bar or mass of steel to which the peculiar properties of the loadstone have been applied, one generally understands that an electric magnet is such a mass of electrified material that is given these peculiar properties by the application of the electric current. A solenoid, however, is an electric dynamic spiral having the conjunctive wires turned back along its axis so as to neutralize that compound of the effect of the current due to the length of the spiral and reduce the effect to that of a series of equal and parallel circular

currents. A magnet then, in simple terms, is a solid attracting body of material, while a solenoid is a hollow coil that has the power of attracting a body of magnetic material into itself or an electric magnetic helix. There are many and varied uses of solenoids in the operation of machinery with both alternating and direct current; but there is quite a difference between a direct-current and an alternating-current solenoid.

At *A*, Fig. 10, is shown the relation between the magnetizing force and the pull of a direct-current solenoid, and at *B* is shown the difference between the direct- and the alternating-current pull as indicated by the position of the core when the pull is greatest. The lift of direct-current series-wound

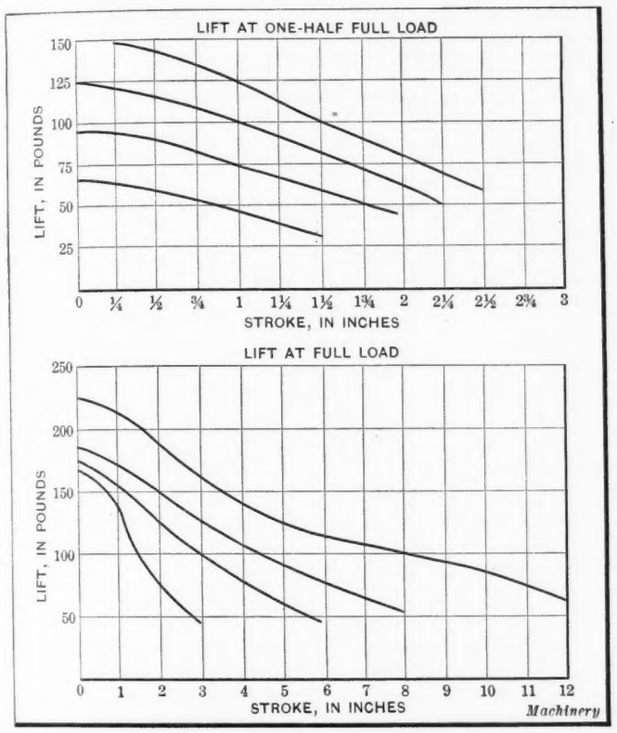


Fig. 11. Lifts of Solenoids at Half and Full Loads

solenoids varies a great deal, as shown in Fig. 11, which indicates clearly the lift at half and at full load.

Experiments with alternating-current solenoids having a long stroke show the erratic behavior of the pull characteristic. If a short stop is used, the pull falls off as the air gap closes until at a certain point it rises very rapidly; if a long stop is made, the pull increases greatly with a decrease in the length of the air gap. The pull of an electromagnet varies as the square of the voltage, so that the effective pull at low voltage falls to less than one-half of what it is at the maximum.

Lifting Magnets

The lifting magnet, Fig. 12, may be considered as a number of magnetic turns enclosed in a casing of cast steel. The coil is a device for transforming electric energy into magnetic potential energy. The greater the number of amperes passing through a given coil, the stronger will be the attractive force of the magnet; the greater the number of turns multiplied with the current, the greater will be the lifting capacity;

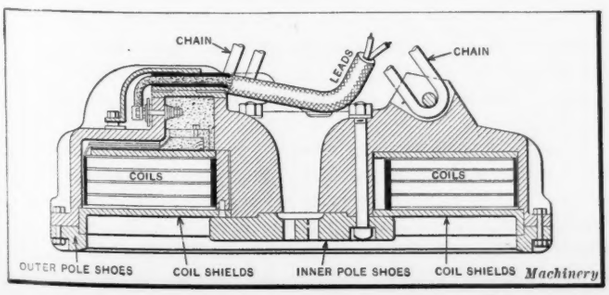


Fig. 12. Outline of Typical Lifting Magnet

and the greater the actual current taken by the magnet, the higher will be its efficiency, since the proportion of the live load to the dead weight will be increased. It is necessary to locate the maximum number of turns in the least possible space and to carry the maximum safe current in the conductors, so that the more current a magnet of a given size uses, the greater is its lifting capacity. The current cost is a small item, and the greatest gain in efficiency is made because of the increasing of the lifting capacity in proportion to the weight of the magnet. Increased lifting capacity means fewer magnets to handle the material, fewer operations, and fewer cranes.

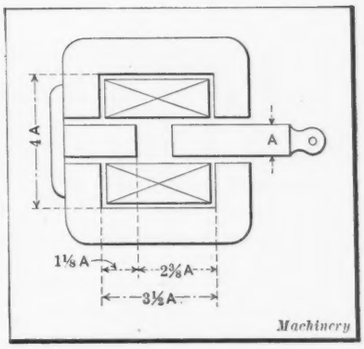


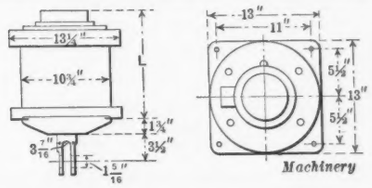
Fig. 13. Proportions of a Standard Solenoid

Proportions and Applications of Standard Solenoids

The proportions of a standard solenoid are shown in Fig. 13; this requires no explanation. The outline dimensions, horsepower, weight, lifting capacity, in pounds, and stroke of a standard solenoid are given in Table 2. One of the many applications of this type of solenoid is shown in Fig. 14, which is a time-limit overload relay with a single dashpot to retard too rapid action; it will be seen that this is an alternating-current apparatus having laminated cores. The function of this apparatus is to break an auxiliary circuit, the contacts being shown at the top, with an overload on either of two phases. Another application of this type is the self-starter shown in Fig. 16; its function is to make a series of electrical contacts, or short circuits. This solenoid has no laminated cores, but has a dashpot to retard too rapid movement.

These solenoids show projecting pole pieces extending to within a certain distance of the upper ends of the coils, which

TABLE 2. PROPORTIONS AND STRENGTH OF SOLENOIDS



Length, Inches	Horsepower	Weight, Pounds	Lifting Capacity, Pounds	Stroke, Inches
7½	2 to 10	205	170	3
11⅝	10 to 30	255	172	6
13	25 to 75	360	185	8
16	50 to 150	405	225	12

give the magnet a great increase in pull as the plunger approaches the stationary pole, so that it will have more power to do the required work. As a result, there is a rapid acceleration of the plunger, so that if a dashpot were not used, the plunger would strike the stationary pole a hard blow; the frequent repetition of these blows would be likely to injure the apparatus.

In the other type of solenoids the plunger practically centers itself when drawn into the coil, as in the case of the instantaneous double-coil overload relay shown in Fig. 17. The pull is up and the auxiliary circuit-breaking buttons at the bottom, so that when either coil is energized the auxiliary circuit will be broken by the plunger being raised away from the contact. Fig. 15 shows a series relay standard, which is considerably used at the present time.

Solenoid-operated valves are designed for use where it is desired to operate a valve from remote points, or automati-

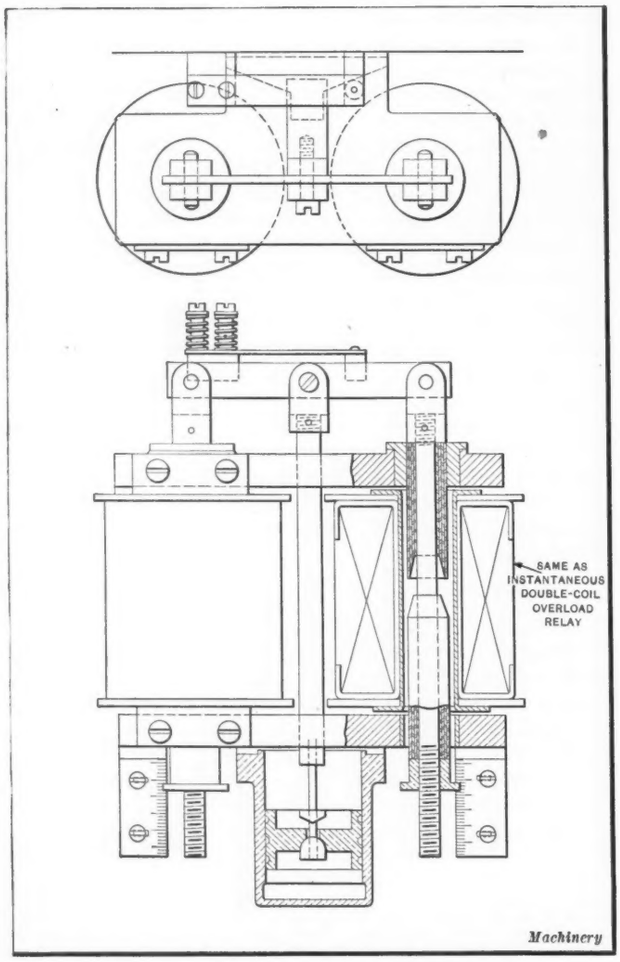


Fig. 14. Time-limit Overload Relay

cally, in connection with motor-driven pumps, compressors, etc. These valves may be used on a steam service where the pressure does not exceed 150 pounds per square inch. They are built in four sizes, 3/8, 1/2, 3/4, and 1 inch, are threaded for standard cast-iron pipe, and have an area of opening equal to that of the pipe. These valves are used for three types of service: continuous, the coils of which will stand the full rated voltage continuously without overheating; intermittent, the coils of which will stand the full rated voltage applied for not over seven out of each thirty minutes; and momentary, the coils of which will stand the rated voltage applied for not over two out of every thirty minutes. When operated from a distance, a knife or snap switch is used to control the solenoid circuit; and by using a special three-position switch, momentary-duty coils may be used for continuous service, this special switch limiting the control of the valve to one point. A relay is required if it is desired to operate the valve from several points, which necessitates the use of one normally closed push-button or equivalent switches at each station. In the solenoid-operated valve shown in Fig. 18, the body *A* has a projecting boss, onto which is secured the piece *B* carrying the frame *C* with its cap or cover *D*. Inside frame *C* is a solenoid *E*, with its insulator *F* and ends *G*, which have leads *H* that pass through cover *D*. Air spaces *J* and *K* are provided to keep the solenoid cool. The core *L* of the solenoid carries on its end a valve seat *M*, which is held to the stem or plunger by a nut *N* and is held down in the closed position by a spring *O*. When the solenoid is energized, the plunger and valve pass into space *P*, thus allowing the valve to open.

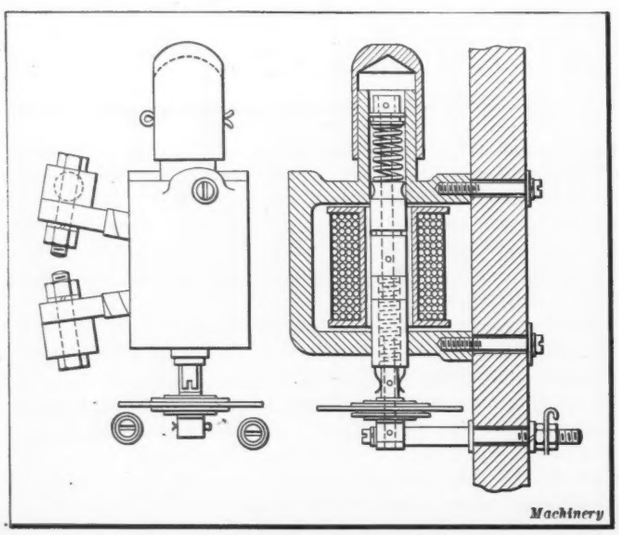


Fig. 15. Common Type of Series Relay

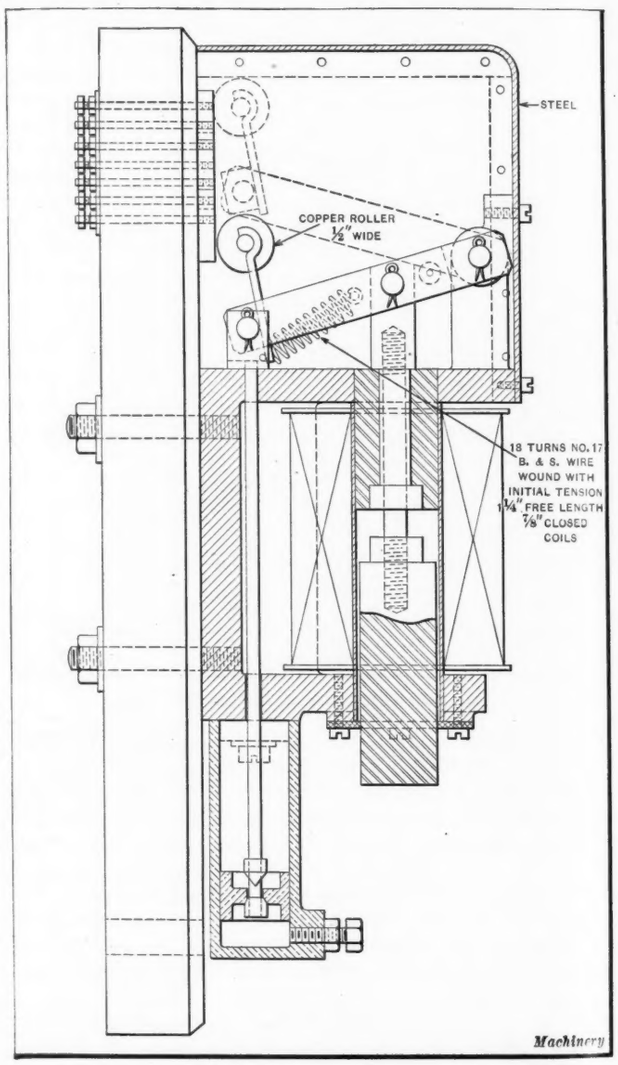


Fig. 16. Application of Solenoid to a Self-starter

One of the most useful applications of the solenoid is in the magnetic shifting-gear device for automobiles, as shown in Fig. 19. This device consists of a housing having at its ends magnetic windings arranged in pairs, shifter bars guided through the ends of the housings and constituting cores for the end windings, or solenoid and pole pieces for one set of intermediate windings whereby each bar may occupy three positions, with dogs adapted to lock the bars in their respective positions and to be released by another set of intermediate windings.

Table 3 gives the rating of shunt-wound solenoids, voltage, sizes, weights of plungers, in pounds, weight lifted for intermittent and continuous service with no cut-out, intermittent service with cut-out, and periodic service with no cut-out. These weights are the amounts that can be lifted in addition to the plunger. Table 4 gives the stroke, in inches, and weights lifted at half and full loads of series-wound solenoids.

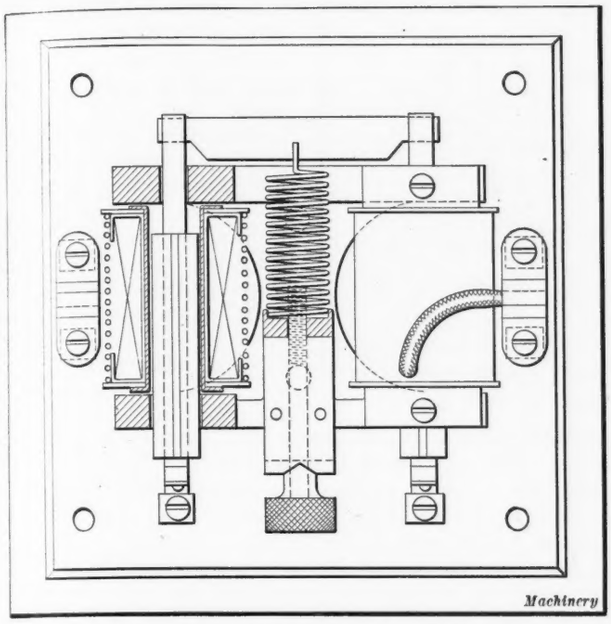


Fig. 17. Instantaneous Double-coil Overload Relay

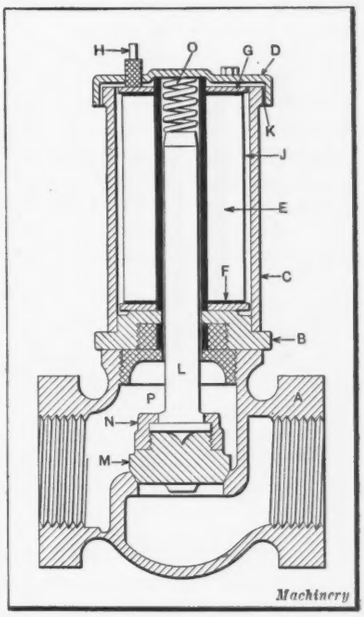


Fig. 18. Globe Valve with Solenoid

The horsepower of these solenoids for both standard crane and continuous service is given in Table 5. In Table 6 are given the proportions of another standard solenoid; the pull, number of turns, amperes, and travel of plunger of this solenoid are given in Table 7.

The method generally used in designing electric magnets is as follows: Decide upon the total number of lines of force required and the material to be used for the various parts of the magnetic circuit; then select the magnetic densities, from experience, and obtain the corresponding values of the magnetizing forces from the magnetization curves for the materials used. The sectional areas of the various parts are found by dividing the total flux by the flux densities, and the length of each part is made as short as possible.

The length of the cores depends on the length of the magnetizing coils, which, in turn, depends on the number of turns, the size of the wire, and the depth of the winding. The depth of the winding must be such that the surface of the coil will not radiate more than from 1/2 to 1 watt per square inch. If the lengths of the iron parts are estimated first, they may be corrected afterward if necessary. Since it is the air gap that usually requires the greatest number of ampere-turns, a slight variation in the length of the iron parts will not affect the results much.

Having the areas, lengths, densities, and magnetizing forces for the various parts, the ampere-turns required to produce the given flux in the various parts may be calculated or obtained from ampere-turn curves. The sum of the ampere-turns for all the parts gives the total number of ampere-turns required. Having the current and the number of ampere-turns required, choose a conductor for the coils having such a resistance as to allow the desired current to flow without undue heating. Excessively large conductors must not be used, as it will make the coil too large, costly, and, perhaps, inefficient,

TABLE 3. SHUNT-WOUND SOLENOIDS. TABLE GIVES WEIGHTS IN POUNDS THAT CAN BE LIFTED IN ADDITION TO PLUNGER

A—Intermittent service with no cut-out; B—Continuous service with no cut-out; C—Intermittent service with cut-out; D—Periodic service with no cut-out.

Lift, Inches	Size 1, 31-pound Plunger												Size 2, 43-pound Plunger											
	110-volt				240-volt				550-volt				110-volt				240-volt				550-volt			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
½	129	39	234	181	103	19	209	160	89	9	199	160	127	47	237	180	107	57	214	160	92	37	202	161
1	109	19	231	176	82	5	206	154	69		193	154	120	32	237	172	98	37	212	152	84	25	198	154
1½	69		226	167	46		201	134			184	130	105	14	235	165	84	23	210	145	67	7	192	145
2	39		219	154	23		192	111	16		165	83	79		232	161	67	7	206	137	47		185	133
2½	27		209	112	11		169	74	3		124	62	62		229	151	53		202	127	30		174	127
3	13		194	73	6		119	49			77	30	52		222	142	37		195	119	17		162	104
4			84	33			54	19			39	10	31		203	120	17		177	97			143	92
5			34	4			19				9		17		189	94	2		152	81			133	72
6															163				129				98	
8																								
10																								
11																								

Lift, Inches	Size 3, 45-pound Plunger												Size 4, 52-pound Plunger											
	110-volt				240-volt				550-volt				110-volt				240-volt				550-volt			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
½	132	64	245	181	119	72	220	162	107	62	210	170	148	84	278	211	132	82	238	180	120	75	245	172
1	127	52	245	178	108	55	220	157	91	45	210	164	143	60	275	208	115	58	236	175	102	48	242	168
1½	120	35	245	172	91	35	218	150	75	33	205	155	121	34	272	201	95	31	235	168	88	25	235	156
2	100	12	245	165	75	20	215	145	55	10	197	141	101	21	266	193	76	17	231	156	62	8	225	144
2½	82		242	160	60		213	133	42		190	125	83		258	172	62		225	140	45		212	128
3	70		237	155	49		211	124	26		182	112	71		248	160	48		217	124	34		195	108
4	55		227	145	33		198	105	15		170	95	55		233	150	31		202	108	18		178	90
5	43		222	135	23		188	95	2		160	85	44		225	143	20		194	92	4		171	81
6	35		213	125	13		182	82			152	75	34		224	141	13		186	82			166	76
8													21		218	128	3		158	65			150	61
10													8		179	93			123	44			108	37
11															115	68			75	28			61	22

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because the outside turns will be too far from the core, or the coil will be unnecessarily long.

If the voltage is known, the size of the conductor may be calculated and the mean length of turn obtained by the formula:

$$A = \frac{12LT}{E}$$

where A = area, in circular mils;
L = mean length of turn, in feet;
T = ampere-turns;
E = difference in potential across coil.

At first calculate only approximately the mean length of one turn, and later a more correct value may be used to find A.

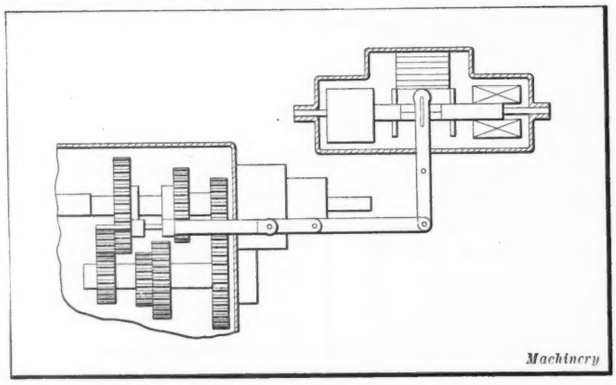

Fig. 19. Magnetic Gear-shifting Device

* * *

SPONTANEOUS COMBUSTION

Spontaneous combustion, more correctly called "spontaneous ignition," refers to a condition where ignition takes place without the employment of any external source of heat. The spontaneous ignition of coal when stored in large quantities is well known, and at the present time, when there is such a serious shortage, great care should be taken in the storage of coal to prevent such ignition and consequent waste.

Spontaneous ignition is probably the cause of many fires, the starting of which cannot be adequately explained. One of the commonest forms in which spontaneous ignition takes place is when a fire starts from a piece of cotton waste or an old rag saturated with oil and left lying in a warm place. Boiled linseed oil is the most dangerous of the oils commonly found around industrial plants. The spontaneous ignition from an oil-soaked rag or waste which has been left in a warm room or in the sun is caused by the rapid oxidation of the oil spread out over the large surface afforded by the threads in the waste or the folds of the cloth. The greater the exposed surface the more rapid the oxidation, until finally the temperature rises sufficiently to cause the oil and waste to ignite and burn with a flame. Mineral oils are not considered dangerous in this respect, but nevertheless the precaution of keeping all oil-soaked waste in metal receptacles should always be observed.

TABLE 4. SERIES-WOUND SOLENOIDS

Figures in table give weights lifted at half and full loads: Y = half load; Z = full load

Stroke, Inches	Size 1, 31-pound Plunger																		Size 2, 43-pound Plunger							
	A		B		C		D		E		O		P		Q		R		F		G		H		S	
	Y	Z	Y	Z	Y	Z	Y	Z	Y	Z	Y	Z	Y	Z	Y	Z	Y	Z	Y	Z	Y	Z	Y	Z	Y	Z
½	23	109	25	119	26	129	44	144	46	159		30		40		53		60	37	117	44	123	55	135		61
1	9	89	9	94	13	109	23	123	27	139		22		27		34		40	22	105	30	110	39	122		42
1½		49		59		69	3	86	3	99						9		11	7	90	15	97	25	110		18
2		29		35		39		49		59										75	3	82	13	97		
2½		9		19		26		35		44										62		70		85		
3				6		13		19		23										42		52		71		
4										3										27		36		56		
5																				17		26		47		
6																										
8																										
10																										

Stroke, Inches	Size 3, 45-pound Plunger														Size 4, 52-pound Plunger					
	I		J		K		L		M		T		U		N		V		W	
	Y	Z	Y	Z	Y	Z	Y	Z	Y	Z	Y	Z	Y	Z	Y	Z	Y	Z	Y	Z
½	60	125	63	135	70	137	75	145	78	148	12	77	26	87	91	168	14	81	25	94
1	45	120	52	127	55	130	62	137	65	142		62	12	75	74	164		48	10	74
1½	30	112	25	115	40	125	42	132	52	135		42		55	48	152		36		88
2	10	95	15	105	22	110	30	119	32	124		23		40	28	135		15		31
2½		82		91		95	7	105	12	118		7		30	8	120				18
3		70		80		85		95		102				15		103				13
4		52		62		67		80		85				2		85				
5		40		49		55		65		72						75				
6		30		39		45		57		62						64				
8																54				
10																33				

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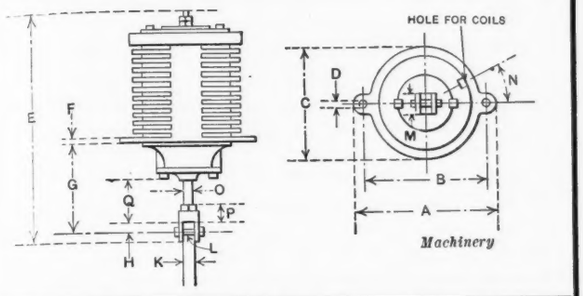
TABLE 5. HORSEPOWER OF STANDARD CRANE AND CONTINUOUS SERVICE

The letters indicating classification of solenoids are those used in Table 4

Size 1, 31-pound Plunger							Size 2, 43-pound Plunger							Size 3, 45-pound Plunger							Size 4, 52-pound Plunger						
Horsepower	Crane Rating			Continuous Rating			Horsepower	Crane Rating			Continuous Rating			Horsepower	Crane Rating			Continuous Rating			Horsepower	Crane Rating			Continuous Rating		
	110 Volt	240 Volt	550 Volt	110 Volt	240 Volt	550 Volt		110 Volt	240 Volt	550 Volt	110 Volt	240 Volt	550 Volt		110 Volt	240 Volt	550 Volt	110 Volt	240 Volt	550 Volt		110 Volt	240 Volt	550 Volt	110 Volt	240 Volt	550 Volt
2.0	C	C	A	R	Q	Q	10	G	F	F	S	S	S	25		M	M		T	T	50	N	N	N		V	V
3.5	E	D	D	O	P	O	15	F	F	F	S	S	S	30		L	L		T	T	75		N	N		V	V
5.0	D	C	C	R	Q	R	20	F	G	F	S	S	S	35		J	K		T	T	100		N	N		V	V
7.5	E	B	B	R	P	Q	25		H	F		S	S	50		I	M		T	T	125		N	N		W	W
10.0	C	D	C	R	R	Q	30		F	F		S	S	75		I	L		T	T	150		N	N		W	V

Machinery

TABLE 6. PROPORTIONS OF A STANDARD SOLENOID



Plunger Diameter, Inches	3¼	4	4½	5½	6 5/16	7
Plunger Weight, Pounds	12	19	28	45	60	80
Total Weight Lifted, Pounds	160	230	325	400	495	565
Dimensions, Inches A	11	12	13¼	15	16¾	17¾
B	9¼	10¾	11⅞	13¼	14¾	15¾
C	8⅞	9 13/16	10⅝	12⅝	13¼	14¼
D	17/32	17/32	17/32	21/32	25/32	25/32
E	18½	19 5/16	21½	23¾	24 1/16	24¾
F	⅝	¾	¾	13/16	15/16	1
G	7¼	7¾	9½	10½	10 13/16	11¼
H	1	1	1	1¼	1¼	1¼
K	1	1	1	1 3/16	1 3/16	1 3/16
L	½	½	½	¾	¾	¾
M	1¼	1¼	1¼	1¾	1¾	1¾
N	30°	90°	25°	29°	28°	28°
O	⅝	¾	¾	⅞	⅞	1
P	1⅜	1¾	1¾	2¼	2¼	2¼
Q	3 7/16	3¾	4 1/16	4⅜	4 5/16	4 5/16

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USE OF BISMUTH

Bismuth is not widely used, partly because of its high price and partly because of its brittleness, which prevents its use for anything that must be tough or malleable. It has two qualities, however, which render it useful for certain purposes. It expands on solidifying from the molten condition, and is, therefore, sometimes used in type metal. It also gives to alloys in which it is used a low melting point, and for this reason is used in the alloys employed in automatic sprinkler heads, in fuses for electric wiring, and in solders. It is also used to some extent in bearing metals.

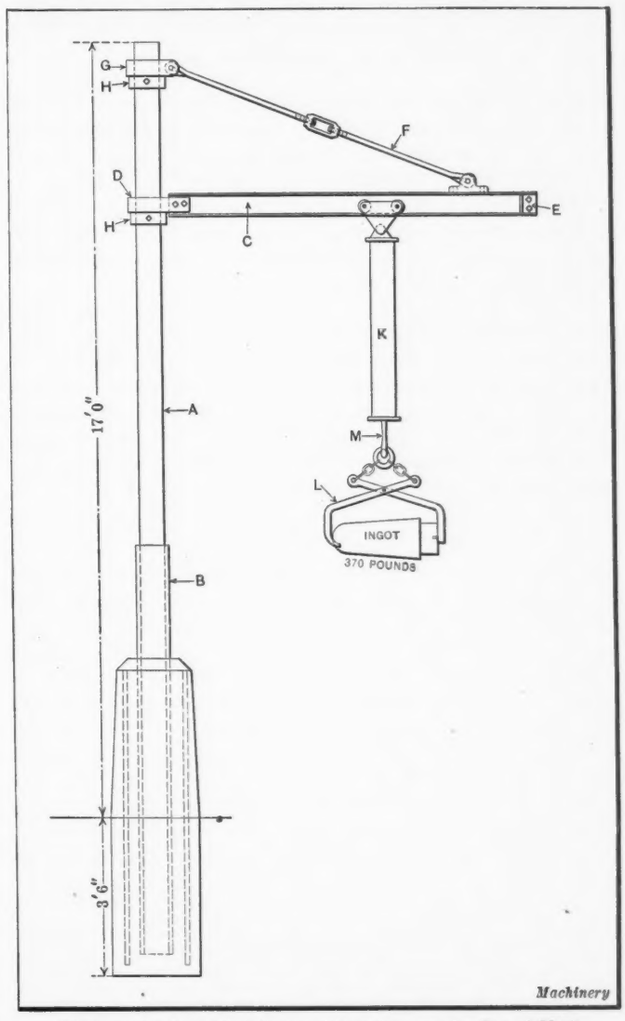
TABLE 7. PULL, AMPERE-TURNS, AND TRAVEL OF PLUNGER OF STANDARD SOLENOID

Number of Turns	Amperes	Number of Turns	Amperes	Pull, in Pounds, with Plunger Travel of 1/4 in.	1/2 in.	3/4 in.	1 in.	1 1/4 in.	1 1/2 in.
72	41.7	99	30.3	109	51	22	2	...	...
72	55.5	99	40.4	140	82	46	26	12	...
72	69.4	99	50.5	165	112	72	44	28	13
72	83.3	99	60.6	...	140	96	63	42	25
72	41.7	99	30.3	164	75	32	5	...	...
72	55.5	99	40.4	211	128	68	38	17	...
72	69.4	99	50.5	236	168	107	66	32	18
72	83.3	99	60.6	...	204	144	96	63	37
50	60.0	72	41.7	215	97	41	5	...	...
50	80.0	72	55.5	278	163	89	46	19	...
50	100.0	72	69.4	330	222	141	86	52	22
50	120.0	72	83.3	...	226	288	125	82	47
37	81.5	50	60.0	323	142	58	3	...	...
37	108.0	50	80.0	415	242	130	70	28	...
37	135.0	50	100.0	491	330	207	128	77	30
37	162.0	50	120.0	...	403	279	181	118	67
26	115.0	35	85.6	422	190	77	8	...	...
26	154.0	35	114.0	540	315	171	52	38	...
26	192.0	35	143.0	653	440	278	168	104	40
26	230.0	35	171.0	...	527	372	243	160	90
18	166.0	26	115.0	528	232	91	6	...	...
18	222.0	26	154.0	694	397	209	115	41	...
18	227.0	26	192.0	807	543	341	209	124	45
18	332.0	26	230.0	...	653	457	295	198	115

JIB CRANE FOR USE IN AN OPEN FLOOR SPACE

The crane shown in the accompanying illustration was designed for use in an open floor space where no supports could be attached to the top of the mast. The requirements were that the crane should raise the 370-pound ingots of 9.2-inch shells four feet, from a platform near the ground line, by means of an air hoist and release them at machines for nicking the ends. Afterward, the ingots are placed under a drop-hammer, the nicked ends broken off, and the fractured part inspected.

The mast consists of a six-inch XX pipe *A* set in a reinforced concrete footing and surrounded by an eight-inch XX pipe *B;* the space between the pipes is filled with grouting. The boom *C* is a six-inch I-beam. Bolted to one end is a cast-steel yoke *D* that is bored out large enough to revolve freely on the outside of the mast; the other end is provided with a stop *E* to prevent the hoist from running off. The tie-rods *F* are made of 1-inch iron and are provided with turnbuckles to take up any necessary adjustment. One end of the tie-rod is secured to a cast-steel yoke *G* fitted loosely around the mast



Jib Crane for Open Floor Space without Supports for Top of Mast

similar to the yoke on the end of the I-beam. Cast-steel collars *H* securely fastened to the mast are placed under each yoke piece. The air hoist *K* is 4 inches in diameter, has a 4-foot stroke, and a capacity of 1000 pounds. The tongs *L* attached to the hook *M* on the air hoist are made of forgings. One of the pair has a pin on one end, which fits in a punched hole in one end of the ingot, the other one of the pair has one end bifurcated to fit around the nose of the ingot. G. W. C.

* * *

During the year 1917, the capitalization of new American corporations formed was the largest on record. In the eastern states alone, the new companies chartered had an aggregate capitalization of $3,714,105,000.

EYE PROTECTION IN THE MACHINE INDUSTRY[1][2]

CAUSES OF INJURIES TO THE EYE AND METHODS BY WHICH SUCH INJURIES MAY BE PREVENTED

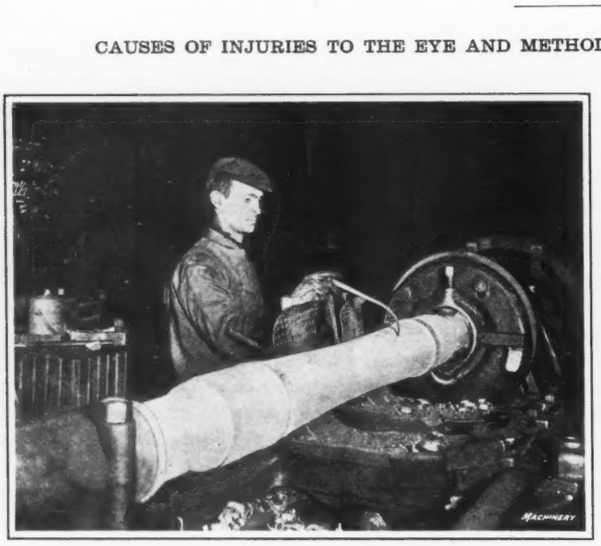


Fig. 1. Guards on Lathe to catch Steel Chips from Tool

OUT of 710,571, or one-third, of the non-fatal accidents occurring annually in the United States, 59,436 are injuries to the eye; and in the nation as a whole it is estimated that 200,000 persons annually receive eye injuries. In the decade from 1880 to 1900, which was one of great industrial growth, blindness increased 25 per cent; while approximately 15,000 persons become blind as a result of injury in industrial occupations each year.

Hazards to the eyesight of industrial workers are found chiefly in the following industries and occupations: the manufacture of iron and steel, machine operations, chipping, grinding and polishing, riveting, welding and cutting, mining and quarrying, sand-blasting, woodworking, and where there is exposure to irritating and poisonous dust or fumes and gases, or to intense light and heat. These are not cited in the order of their importance as productive of eye accidents.

Chipping and Machine Operations

In chipping operations there is always danger of the eyeball being penetrated by flying slivers of metal, which sometimes have such velocity that they penetrate very deep and have been known to lodge in the optic nerve. The use of goggles is the most effective means of preventing accidents from this cause. Goggles for chippers usually have side screens for the deflection of chips coming from a lateral direction, but the tendency is to eliminate these side pieces and place screens between adjacent workers. The side pieces contribute to the steaming of the goggles and cause discomfort because of their weight and appearance; steaming, however, may be prevented by the use of the glycerine pencil or a composition of similar nature. Also a sweat-band around the forehead or attached to the top of the goggles to absorb the moisture and prevent perspiration from running into the eyes will help relieve the difficulty. In some shops the soft metal chips are broken off with a hammer instead of being removed by the chisel. By this plan is avoided the hazard from the great velocity given the chips when they are removed with the air-hammer chisel. Moreover, such remnants as must be removed by the latter process are much smaller than the original chips.

Cutting and turning metal in machines produces flying chips, which cause many eye injuries. In the machining of rough castings there is also the hazard of flying sand that has adhered to the metal. As a result, the workmen often rig up protective screens of different kinds; but these in many cases are the cause of accidents. However, a guard properly designed, if made of good material and carefully fitted to the tool-rest, will be found an effective preventive. Two satisfactory types of guards are shown in Figs. 1 and 2.

Grinding and Sand-blasting

Statistics compiled by casualty companies show that in recent years there has been a large increase in the number of accidents resulting from the operation of abrasive wheels. This increase is undoubtedly due to the greater use of abrasives, to the failure to provide protective devices, and to the failure of employes to use such devices when the wheels have been equipped with them. The hazards incident to grinding are those due to abrasive dust, fine particles from the work surface that is being ground, and flying parts of a wheel that has been ruptured by an accidental blow. These accidents are rarely unavoidable, and the application of substantial guards, hoods, and exhaust systems to the wheels and the wearing of goggles by the grinders will reduce the number to a minimum. The effectiveness of goggles is shown in Fig. 3. If, for any reason, it is impracticable to equip a wheel with a hood, safety flanges should be used. These bind the wheel on each side and are adapted for straight or tapered wheels. Then, in the event of a rupture, the parts of the wheel are clamped by the flanges.

Goggles should always be worn by grinding machine operators, even when a grinding wheel is protected by a suitable guard. A possible exception, however, is when doing certain kinds of wet precision grinding, for example, automobile crankshafts. Then the point of contact between the grinding wheel and the work is always under a large stream of water, which carries into the tank of the grinder any particles that might otherwise cause eye injuries. The goggles for this work need be neither heavy nor cumbersome; the thickness of the lens should be based upon the kind of grinding on which the workman is engaged. Side screens are of value where protection is necessary to offset the danger of chips from adjacent machines. Flying abrasive particles are white-hot, so when they strike the eyeball they are likely to burn their way into the tissues, thus making their removal more difficult. Though the heat may cauterize the edges of the wound, there results an abrasion that makes it far more easy for bacteria to enter and bring about serious infection.

In numerous plants a pair of goggles is hung beside a grinding wheel for any employe who may use the wheel. This promiscuous interchange of goggles exposes workmen to communicable diseases of the eye. Occasionally a pair is known to have been last worn by a man who had sore eyes. The fac-

Fig. 2. Glass Chip Shield on Lathe

[1] Extracts from a report by the National Committee for the Prevention of Blindness

[2] For other articles in MACHINERY on eye protection, see "Eye Protection for Grinders and Machinists," March, 1915; "Proper Eye Protection," December, 1914.

tor responsible for the inflammation may not be known even to that employe himself, so that any workman who wears these goggles may later develop trachoma or some other serious eye disease.

Dust should be carefully removed from the grinding machines. Constant breathing of air laden with abrasive dust is injurious, and there is an accumulative hazard to eyesight from the constant scarring of the cornea by these fine particles. An exhaust system carefully planned and approaching as close as possible to the source of the dust should be installed wherever much grinding is done.

Frequently the most serious hazard is apparent in shops where the grinding wheels are used only occasionally, perhaps for but a few minutes in a day to touch up some dull tool or to grind off a burr from a casting. In shops where abrasive wheels are in constant use the severity of the hazard is appreciated far more.

Sand-blasting of large areas is generally accomplished by the use of the hose type of apparatus, which permits a stream of sand to be shot with great force against the casting or other object. The operators must be afforded protection for the eyes and face, for the sharp particles of sand are driven with such force against the surface operated upon that they rebound many feet and the surrounding air is constantly filled with dust produced by the driven sand and that removed from the surface being cleaned. Because the particles of silicious sand used would rapidly pit the glass surface of goggles, the helmets provided for the workmen should have windows of fine-wire mesh, mica, or celluloid through which the operator may watch his work. Sometimes these helmets are connected by a hose to a compressed air system in order to give the operator a constant supply of fresh air. Where such equipment is used, care should be exercised that there is not too strong a pressure of moist air, which, in itself, is a hazard to the health of the worker. The eye hazard from irritating dust may be offset if the work is held in a box-like hood with small openings through which the workman puts his hands and arms. These hoods are equipped with exhaust fans to carry off the dust, while glass windows enable the operator to watch his work.

Dangers from Mushroomed Tools

Swages, flatters, fullers, breaking-down tools, chisels, etc., are often used until the heads have spread and split, as shown in Fig. 4. Each blow upon such a mushroomed surface may cause chips to fly off with sufficient force to destroy an eye or to pass through the clothing and into the flesh. Mushrooming may occur on the finest hand-forged tools, as well as on those with the cast heads commonly provided in cheap hammers. An injury of this nature, when caused by a small particle of steel, may seem of little moment at the time; even when the particle has penetrated to the interior of the eye, its presence and effect may be at first non-apparent. Serious infections, however, may result from injuries of this nature when

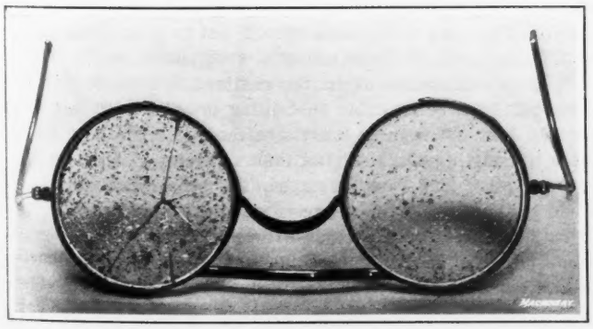


Fig. 3. Emery Particles fused to Goggles

the penetrating particle has carried dirt or germs into the interior of the eye. The location of particles of iron and steel can often be determined only by the use of the X-ray and a steel sliver can frequently be withdrawn only by an electric magnet. One authority has stated that it is often necessary to remove the injured eyeball in order to save the other eye, as the irritation set up is frequently transmitted to the good eye and thus, through sympathetic inflammation, leads to blindness. The good eye may be affected at any time from a few weeks to thirty or forty years after the injury.

Constant watchfulness on the part of workmen and foremen is essential in order that hammers and tools may be kept properly dressed. The National Safety Council recommends the establishment of a regular tool-room for a certain number of employes, which should be in charge of a competent workman. This man should see that all tools are dressed, ground, and properly repaired, and that they are inspected at least once a

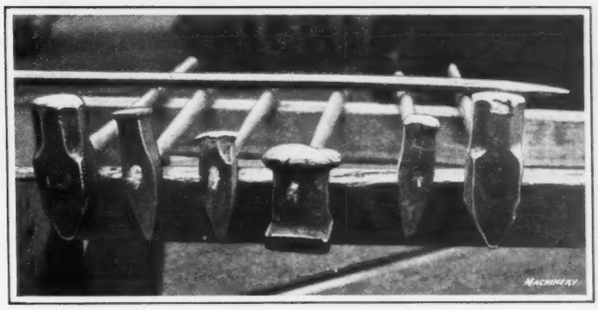


Fig. 4. Examples of Mushroomed Tools

week. Such tools as air-hammers, electric machines, etc., should be examined every evening for oiling, testing for grounds, etc.

Radiations from Intense Light and Heat Sources

The injurious light radiations furnished by the most powerful commercial illuminants are too small to be dangerous under ordinary working conditions, even when these illuminants are accidentally used without their globes. Artificial illuminants may prove very tiresome through the sharp contractions of the pupil that they produce, and through the premature, though generally temporary, exhaustion of the retina, but, generally speaking, any intense light results in fatigue and inefficiency rather than in demonstrable harm. However, workmen exposed to the radiant energy in arc-welding and in molten metal should be protected by colored goggles. After exposure of the eye to injurious radiations, there is a latent period before any effects become perceptible; this period varies with the severity of the exposure, but the injury is usually apparent within twenty-four hours. The light radiations, however, do not permanently injure the eye; in fact, they seldom cause anything more than a mild inflammation, which disappears in a day or two.

However, the intense light and heat produced in arc-welding, oxy-acetylene and oxy-hydrogen welding, and other operations in which molten metals are concerned, may be quite harmful. Arc-welders must be protected not only from the intense light and heat, but also from the fine particles that fly off from the electrode. In this work there is always a tendency to oxidation and the formation of cinder, and the imprisoned air, bursting its way out of the contact surface, may be the cause of just as serious an injury as the cinders of the hand process of welding.

Welding and cutting by high temperature media should be done in a room separated from other work-places. However, dependence should not be placed on the canvas curtain walls sometimes used. Wear and tear will make such curtains practically worthless, as a means of protecting other workmen from the glare, within a very short time. The operators should be provided with goggles both as a protection against splashes of molten metal, flying sparks, cinders, etc., and against the radiations from superheated metals and high-temperature welding media. Without goggles, there will result marked inflammation of the mucous membranes of the eye, annoying after-images, light-flashes, headaches, and temporary blindness, with consequent loss of time and wages.

The goggles provided generally have dark blue, smoke, or red glasses; unfortunately, these colors are far from being effective. The cobalt-blue glasses especially give but a hazy view of the furnace interior and molten metal and do not absorb those radiations that are at least excessively fatiguing to the eye. Goggles for protection in these operations should

provide sufficient reduction of the intensity of the light, should be effective in absorbing the ultra-violet rays, should keep the eye cool, and should transmit as much as possible of the visible spectrum without color distortion. It is an advantage also if the color of the goggle itself is inconspicuous. It has been found that of the infra-red rays emitted by a furnace heated to 1000 or 1100 degrees C., about 99 per cent are obstructed by gold-plated glasses; about 95 per cent, by sage-green or bluish-green glasses; about 60 to 80 per cent, by very deep black glasses; and about 60 per cent, by greenish-yellow glasses. At higher temperatures these data would be somewhat different.

For working molten quartz, operating oxy-acetylene or electric welding apparatus, searchlights, or other intense sources of light, the darkest glasses, whether black, green (not including gold-plated glasses), or yellowish-green should be worn in order to obstruct not only the infra-red, but also the visible and the ultra-violet rays. For working near furnaces of molten iron or glass, if considerable light is needed, a light bluish-green or sage-green glass is advised. Unfortunately, the cost of gold-plated glasses puts them as yet rather out of the range of availability for industrial purposes, and the effects produced in looking through them are not quite so pleasing as through the sage-green ferrous glass.

For outdoor welding, such as work on steel rails, there is a simple protective device in the shape of a small box beneath which the work is accomplished. Correctly tinted glass windows in the box enable the welder to watch his work safely and protect passers-by from injury from the light source or from flying chips and sparks.

Removal of Foreign Substance from Eye

Thousands of infected eyes are due to the neglect of workmen to have foreign substances removed from them immediately. Some of the most dreaded systemic diseases may find a point of entrance through a tiny wound thus caused in the cornea, the individual being in all respects entirely normal and in good health. Another source of infection is the attempt of fellow-workmen to remove substances from the eye. For this purpose the friend may use a soiled handkerchief, match, etc., and in his effort to remove the substance, it may be moved considerably, abrading the surface of the eye. In the abrasion thus formed, micro-organisms from the probe may enter.

For the removal of dust and dirt or when any foreign body is embedded in the eye, the lids should be gently separated and the eye flushed with boric acid or normal salt solution, followed by a couple of drops of a 10 per cent argyrol solution or a small bead of bichloride salve. The eye should then be bandaged and the man sent to a physician.

Treatment of Acid Burns

Wherever workmen are handling acids or chemicals, there should be readily available clean running water to be used for washing hands or irrigating eyes, on which the chemicals may have splashed through accident or explosion. The best first-aid treatment in such an emergency is to lay the victim on his back and thoroughly irrigate the eyes, lifting the lids and enabling the water to reach as far under them as possible. A small flexible hose, from which a moderate jet of water can be directed into the eyes, should be at hand. If no better way is evident, plunge the head into a pail of water and open the eyes so as to thoroughly cleanse them of the acid. If the works are equipped with first-aid kits, then apply bichloride salve, bandage the eyes, and send for the doctor. The important thing is to dilute the chemical as quickly and thoroughly as possible.

* * *

CENSUS OF BRASS, BRONZE, AND COPPER INDUSTRY

The Bureau of Census of the Department of Commerce recently issued its report of the brass, bronze and copper industry for 1914, indicating that there were in that year 992 establishments employing 45,657 persons. The capital invested was about $116,000,000 and the value of the products about $162,000,000.

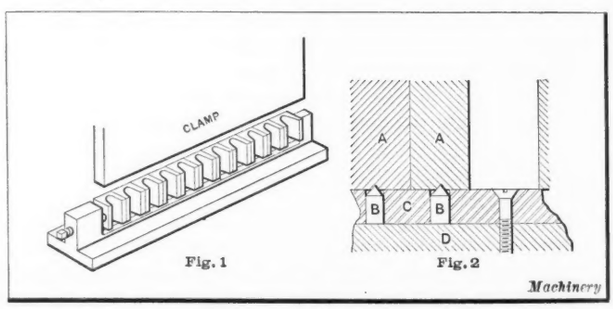
HOLDING PARTS FOR MILLING

BY DONALD A. HAMPSON[1]

In a continuous milling operation on some castings, a simple kink resulted in a marked saving of both time and material. Fig. 1 shows some of the castings placed on the removable platen of the fixture, ready to be clamped down and passed between the two end-mills of a duplex milling machine. One of the sides to be machined is solid, and the other is broken by the slot through the middle of the casting. Because of the shape of the piece, there is an uneven cut and the feed sets up a turning moment, with the result that the pieces, in moving, are cut a few thousandths inch under size and spoiled. Before going to the milling machine, the top and bottom faces of the pieces are roughly ground by pushing the pieces between a gage strip and an emery wheel of the ring type, which leaves them approximately square and of the same size.

If one or two pieces only were clamped, the pressure was so distributed, or rather concentrated, that they would not move under the heaviest cut; but with a dozen pieces there were always three or four that would not be tightly held. The problem was to get something that would prevent the castings from moving without an individual clamp for each piece. Various means of holding the rows of castings were tried out, all with a view of equalizing the clamping pressure on the different castings—strips of leather, fiber, and bristol board, sectional clamps of the equalizer type, knife-edges the full length of the clamp, etc.—but while they worked part of the time, none was a commercial success. At last the method shown in Fig. 2 was tried.

A steel wearing strip *C* is screwed to the platen, and the castings *A* are placed on it and clamped. The strip is spaced off and drilled at two points under each casting, and short pins of drill rod *B* are set in the holes. One end of the pins is



Figs. 1 and 2. Method of holding Parts for Continuous Milling

flat and backs against the platen *D*, while the other is ground to a 90-degree point; the pin length is such that the point is a full thirty-second inch above the working surface of the strip. When the clamp is brought down, it forces the castings on the pins; and with these two holding points in every piece, there is no turning under a cut. As a result, the "wasters" are limited to the poor castings and the inaccuracies of the machine itself. The pins are hardened and drawn to a dark brown. They are then tough enough not to break, but yet are hard enough to give three month's wear before renewal. They make small indentations in the castings, which do not hurt them but have remarkable sustaining power like a lathe center. It does not require much greater effort on the clamp to force the castings on the pins than to clamp the pieces without the pins, and when clamped, the pieces have the same broad bearing and a light pressure holds them in place.

The question might arise as to why pins are not put in the clamp also so that the castings are held top and bottom. In this particular case, the castings are loaded off the machine and a clamp on the loading fixture sets them on the pins; also, a set-screw at the end of the platen is used to nest the castings. The pins and the set-screw hold the parts during the transfer to the machine, and it was found that pins in the clamp proved a disturbing element, because the clamp was made a loose fit and the castings had been aligned in the fixture, so the second set of pins often changed the setting, and they were unnecessary.

[1]Address: 31 Hanford St., Middletown, N. Y.

INTERESTING THINGS IN METALLURGICAL CHEMISTRY

THE EUTECTIC ALLOY AND CHANGES OCCURRING IN METALS AND ALLOYS WHEN COOLING

BY C. W. STARKER [1]

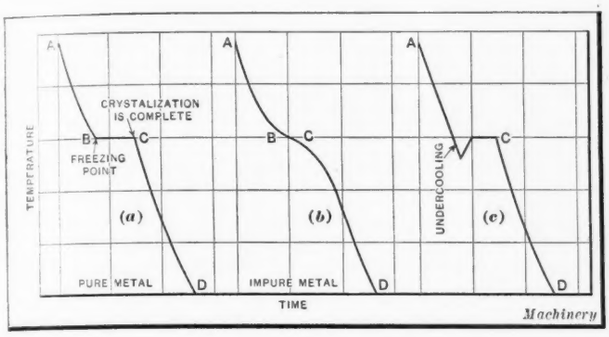


Fig. 1. Time-temperature Curves for Single Metal

WHAT happens to a metal when it is heated and melted is best understood if the conditions are reversed and a study is made of the metal as it passes from the molten into the solid state. Such a study will show, first of all, that the temperature of the molten metal does not decrease uniformly; that is, if plotted as a time-temperature curve, the temperature will not follow a straight line or even an unbroken curve. When the metal has cooled to the point where it begins to crystallize, the temperature remains constant for a time, due to energy being given up in the form of heat by the metal in passing from the liquid to the solid state; after the metal has completely solidified, the temperature again drops. This is shown graphically in the time-temperature curves in Fig. 1. At *A*, the metal is in the molten state; at *B*, the so-called "freezing point," crystallization begins and the temperature remains constant, or practically so, until at *C* the metal has become completely solidified, when the temperature decreases until the point *D* is reached. If this process is reversed and a solid metal is heated from the temperature *D*, by exposing it to a uniform source of heat, the melting point is reached and fusion begins at *C*. Energy is then required to change the state of the metal; therefore, the temperature does not increase until *B* is reached, that is, until the metal becomes completely liquid. Then the temperature increases again according to the amount of heat transmitted to the metal from the outside source.

It will be noted that the slope *CD* is steeper than the slope *AB* because the specific heat is greater for the liquid than for the solid metal; or, in other words, because with increasing temperature of the metal a relatively greater amount of heat is required to raise its temperature further. The specific heat of a metal is the ratio between the temperature necessary to raise the metal and that necessary to raise water 1 degree C. This ratio increases with the temperature attained and is particularly high near the melting point. In raising the temperature of the metal from *D* to *A*, therefore, the slope of the curve *BA* decreases as the temperature of the metal approaches that of the outside heat.

With impure metal, as shown at *b*, the line *BC* is not so pronounced. If a molten metal is cooled slowly, it may cool below the freezing point without solidifying, as shown at *c*; this is known as "undercooling." When the metal then begins to solidify, the heat liberated raises the temperature to the true freezing point. Tin has shown an undercooling of as much as 20 degrees C. In alloys, this undercooling is less; for instance, in a tin-copper alloy it is only 7 degrees.

Changes that Occur During Cooling of Alloys

If the cooling process of a two-metal alloy is studied, it being assumed that the metals do not form a chemical combination, it will be found that, compared with the pure metals, the freezing point has been lowered. This is due to the fact that as one of the metals crystallizes it separates from the other; therefore, as the cooling continues, the liquid alloy becomes enriched with the second metal until it is saturated with this metal; then both metals cool and solidify side by side.

When the point of saturation is reached, there may be said to be two quantities, the excess of one metal and the saturated combination of the two metals; the latter is called the eutectic. Fig. 2 shows the first break in the curve to occur at B_1, where one metal crystallizes; then the excess of that metal and the molten alloy, the proportions of which are changed, cool together until at B_2C_2 they solidify together. The slope of the line B_1C_1 and the rounding at C_1 should be compared with the line *BC* in Fig. 1. The amount of depression of the freezing point has been found to be directly proportional to the amount of the second metal that is added to the first. If, therefore, the two metals are combined in such proportions that from the beginning there is no excess of the first metal to crystallize out, or if there is only a saturated alloy present from the start, there will be the lowest possible freezing point (or, what is the same thing for practical purposes, melting point) of any combination of the two metals. This ideal proportion is called the eutectic ratio, and the saturated alloy is called the eutectic alloy, or the eutectic. Fig. 3 shows time-temperature curves for various proportions of the two metals from the pure metal No. 1 at the left to the pure metal No. 2 at the right. From these curves the eutectic point *F* and the eutectic line *HI* are obtained. Summing up, the characteristic features of the eutectic are that it has the lowest melting point of any proportion in which the two metals may be combined and that this proportion, and therefore the freezing point, is constant.

The two molten metals, in freezing, split up into a conglomerate of crystals of the metals. The photomicrographs shown in Figs. 4, 5, and 6 (taken from "General Metallurgy," by H. O. Hoffman) are made from copper-silver alloys, combined in different proportions. In Fig. 4, the alloy is 20 per cent copper and 80 per cent silver; the photomicrograph shows that it has crystallized in the form of large white patches of silver crystals surrounded by the eutectic alloy. On the other hand, the alloy shown in Fig. 5, which is 70 per cent copper and 30 per cent silver, has, as shown by the dark patches, an excess of copper. In Fig. 6 is shown an eutectic alloy which is 28 per cent copper and 72 per cent silver; there are neither black nor white patches, but a uniform crystalline structure of the eutectic alloy.

Importance of Understanding Transformations During Cooling

The practical importance and influence on manufacturing methods of a clear understanding of the phenomena in connection with proportions of alloys and the predetermination of their most favorable combination with regard to the melting point is apparent, when it is considered that melting means fuel and time, which, in turn, mean money. While the comparatively simple case of two-metal alloys has been described in order to make clear the principal conceptions, the same

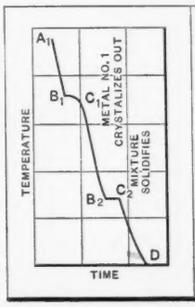


Fig. 2. Time-temperature Curves for Alloys

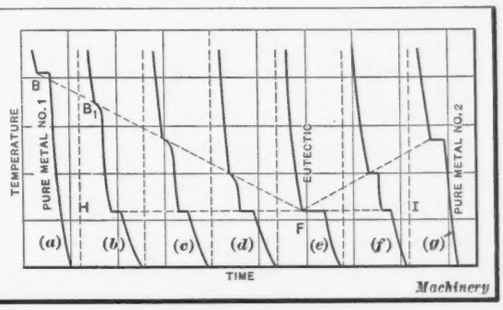


Fig. 3. Time-temperature Curves for Alloys of Different Proportions

[1] Address: 5885 Bartlett St., Pittsburg, Pa.

Fig. 4. Structure of Alloy containing 20 Per Cent Copper and 80 Per Cent Silver

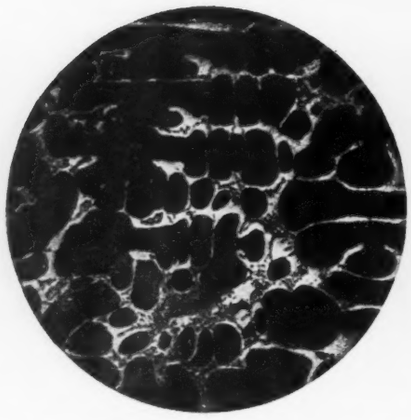


Fig. 5. Structure of Alloy containing 70 Per Cent Copper and 30 Per Cent Silver

Fig. 6. Structure of Eutectic Alloy, containing 28 Per Cent Copper and 72 Per Cent Silver

methods are applied to the study of eutectics for three-metal and four-metal alloys (ternary and quarternary alloys). The graphic demonstration of these alloys becomes, of course, more complex due to the actions and reactions of the different components. The research work on quarternary alloys is still in its early stages, but it is necessary only to mention the alloy steels to show the vast practical importance of this group.

Relation between Physical Characteristics and Melting Point

It is not always desirable, of course, to combine metals in such proportions as to obtain the lowest possible melting point, for the saving in fuel may be offset by the relative cost of the component metals. For instance, in electric brazing (often called welding) the solder generally used has a melting point of about 750 degrees C. and consists of silver and brass. While the melting point may be lowered by increasing the silver content, and the electric current or the time required to perform the operation may thereby be reduced, the cost of the material will rapidly be increased. As far as the physical properties and the electric conductivity of the alloy are concerned, the different proportioning, within practical limits, will be insignificant and of no consequence in most applications. But this is not always the case. For instance, if zinc and copper are combined, the melting point may be decreased by increasing the proportion of zinc. However, an alloy high in zinc might be entirely unsuitable for a given purpose, inasmuch as with increasing zinc content the material becomes more and more brittle. A proportion of fifty parts of copper to fifty parts of zinc, for example, has a melting point of about 875 degrees C. and one of thirty-five parts of copper to sixty-five parts of zinc, a melting point about 820 degrees C., but the former has considerable ductility while the latter is brittle. Different metals act differently in this respect, and there is no definite relation between the physical characteristics and the melting point of an alloy.

If the phenomena that occur in the heating and cooling of metals are thoroughly understood, as well as the influence of the admixture of another metal or metals on the physical properties of an alloy, it is possible to develop an alloy of suitable characteristics for a given purpose. For instance, it is known that adding phosphorus to copper lowers the melting point of the mixture, even when a comparatively small percentage of phosphorus is added, and the eutectic proportion of the two, or the lowest melting point of both metals, is known. As experiments have shown that the phosphorus increases the hardness, lowers the ductility, and darkens the color of copper, the alloy may be proportioned as a hypo-eutectic or a hyper-eutectic alloy; that is, one below or above the true eutectic proportion, in order to combine such physical qualities as may be desired for the particular case on hand with a melting point desirable from a manufacturing standpoint.

That the physical characteristics of a metal or alloy are dependent not alone on the chemical composition is shown plainly by the familiar heat-treating processes of iron, steel, copper, brass, etc. It is also well known what changes are brought about by mechanical treatment, such as rolling and hammering, but it is not so generally appreciated what influence pouring temperature or the rate of melting and cooling has on a metal or alloy. At least such knowledge is frequently not applied in practice. For instance, bearing alloys, so-called "babbitts," are usually classified as tin-base and lead-base alloys. The former consists of about 90 per cent tin, 8 per cent antimony, and 2 per cent copper; the latter, of about 83.3 per cent lead, 8.3 per cent tin, and 8.3 per cent antimony. In former years the tin-base babbitt was considered the only really high-grade bearing lining, but a study of the temperature conditions in using the babbitt showed that the lead-base alloy will not only give an equally good material, but one of superior friction qualities, provided certain precautions are taken. Electric temperature-controlling devices have been developed by means of which the gas flame under the molten metal is regulated and maintained within + or — 5 degrees C. Considering the very high cost of tin, as compared with the cost of lead, it is obvious that many thousands of dollars were wasted in using tin before a study of the changes taking place in heating and cooling of metals led to the correct use of the lead-base alloy.

* * *

STELLITE AS A SUBSTITUTE FOR PLATINUM

The scarcity and high price of platinum has created a demand for a practical substitute. Evidently no single metal or alloy will ever fully replace platinum. The gold-palladium alloy is a close approximation, yet this combination is expensive. Nickel-chromium and silicon-iron alloys, also pure quartz, have given satisfactory results for certain laboratory purposes. Stellite, an alloy composed mainly of cobalt and chromium of varying proportions and malleability, is an excellent substitute for platinum. This alloy possesses the highest red-hardness of any alloy yet discovered. It resists nitric acid almost perfectly, particularly if the chromium constituent is over 15 per cent. It is forged with difficulty at temperatures varying from 750 to 1200 degrees C. In its malleable form, stellite resists chemical attacks, such as hydrochloric, sulphuric, or hydrofluoric acid. Vessels of stellite used for evaporating chemical salts and for boiling caustic alkalies can be made light of section without danger of breakage, since the tensile strength of the alloys is more than 100,000 pounds per square inch. On account of its color, hardness, and retention of luster, stellite may be substituted advantageously for platinum in jewelry. While not as pliant as platinum, it is sufficiently malleable to be worked into many forms without great difficulty.

* * *

According to a statement issued by the Department of Commerce, the imports of gold for the year ending June 30, 1917, were $977,176,026, and of silver $35,003,563; gold exports amounted to $291,921,225 and silver exports to $78,279,931. The net imports of gold during the fiscal year aggregated $685,254,801; in 1916, $403,759,753; in 1915, $25,344,607; while in 1914 there was a net export of $45,499,870.

TRAINING WOMEN MACHINISTS[1]

BY I. C. DECATUR[2] AND H. A. CHASE[3]

Having read with interest the article in the April number of MACHINERY relating to the training of women in machine shop work, it was thought that the experience of the Cummings Machine Works in the training of women as machine operators and machinists would be of interest to the readers of MACHINERY. The Cummings Machine Works in Boston are engaged in the making of ship instruments, general machine work, and experimental work. The nature of the work is such that interchangeable manufacturing methods are applicable only to a small extent, and the women employed, therefore, must be trained not to be mere operators of machines, but to become general all-around machinists. In this respect the requirements of the Cummings Machine Works, therefore, probably differ to a large extent from those of most of the shops in which women workers are now being employed. At the present time about 115 men and 42 women are employed in the shops, but it is intended to increase the working force to about 150 men and 75 women, making the total number of women employed one-third of the working force. The girls are started as apprentices and given a training similar to that of a boy or young man who enters the shop. They are started at a wage of $9 a week and are kept on trial for a period of two weeks. If after this time they show no decided inclination for the work in the shop, they are dismissed, but in case they show ability, either as machine operators or assemblers, they are retained and their pay increased.

Fig. 1. Women operating Shapers in Shop of Cummings Machine Works, Boston, Mass.

It is now nine months since the company began employing women, and during this time only one has left voluntarily, while about ten have been dismissed as not fitted for this class of work. Being pioneers in Boston in the employment of women as machinists, the company has naturally acted as a guide for many other machine builders who have been employing or who are planning to employ women in the shops. The management believes that it is possible to train women to become toolmakers, and several of the girls now in the shop have shown such marked ability that in four years they will probably be as good toolmakers as most men.

At the present time, girls with from five to six months' training turn out in quality and quantity an amount of work equal to about 75 per cent of that of the average man employed, but it is confidently expected that when completely trained they will show 110 per cent efficiency as compared with the men. The principle of equal pay for equal work is being applied, and there is no distinction made in regard to compensation between men and women if they are equally efficient. The women work forty-eight hours per week. It has been found that they do not lose as much time as the men, and their record for being on time is higher than that of the men. The women leave five minutes earlier than the men at noon, as well as at night.

The women coming into the machine shop are recruited from almost all trades and conditions. Dressmakers are found to make good machinists, as well as department store girls and those who have formerly worked in laundries or at housework. Some women with previous experience in munitions work and in the making of typewriters and watches are also employed. Very strict discipline is maintained, but there has been no difficulty in maintaining proper conditions in the shop. The men have accepted the entry of the women into this work as a matter of course, and have proved willing to help and instruct newcomers. No conversation except that relating to the work is permitted during working hours, and social conversation between men and women is also forbidden on the premises during noon hours.

The most desirable age has been found to be between twenty-

[1] See also "War Work for Women," in MACHINERY, April, 1918; "Women Workers in Machine Shops in Great Britain," March, 1918; "Increased Employment of Women in the Industries," February, 1918; "Women Workers in the Shop," January, 1918; and "Women War Munitions Workers," June, 1917.

[2] Manager, Cummings Machine Works, 110 High St., Boston, Mass.

[3] Superintendent, Cummings Machine Works, 110 High St., Boston, Mass.

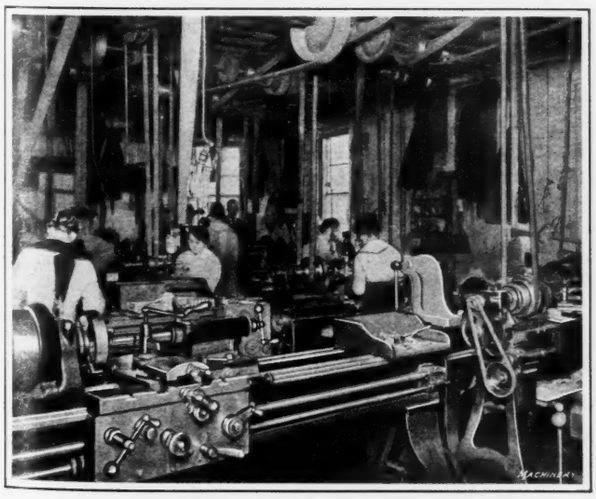


Fig. 2. Women operating Lathes in Cummings Machine Works

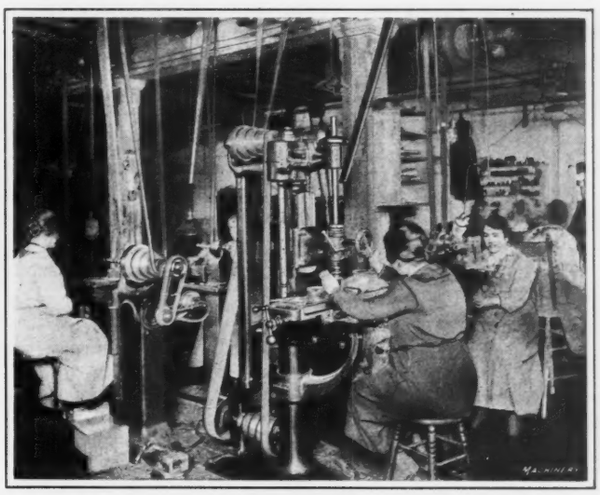


Fig. 3. Women engaged in Miscellaneous Machining Operations

two and thirty. Those that are younger are not serious-minded enough to apply themselves properly to their work, and those over thirty do not seem to have the nimbleness either in their mind or in their hands to take proper hold of the work. No difference has been found according to nationality. American and foreign-born girls are doing equally well, and on the whole it might be said that it has been found that the girls are more willing to work than the class of men which at the present time is obtainable in the labor market.

* * *

ADVANTAGES OF STEEL OVER CAST-IRON PULLEYS

BY W. F. SCHAPHORST[1]

Many machinists believe that a cast-iron pulley is just as good as a steel pulley. However, an investigation into all the conditions will indicate that the steel pulley has many advantages. All pulleys should be strong and tough. Cast iron is strong in compression but not in tension, but steel is strong in both tension and compression, and its ultimate strength is double that of cast iron. Its resistance to shearing is also much greater. Steel is also tough, whereas cast iron is brittle. All machinists have experienced the ease with which cast iron breaks and know the result of a sharp blow on any part of a cast-iron pulley. A broken cast-iron pulley may seriously injure one or more workmen, let alone putting the machinery out of operation. The steel pulley would, therefore, seem to be the logical one from these two standpoints alone, neglecting all others. If a steel pulley is dented or bent, it is not put out of commission, but may be repaired.

Where speeds are high, centrifugal force also comes into action and the cast-iron pulley is likely to burst because of its weakness or brittleness. Steel pulleys can be run at higher speeds than any other metal pulley and are recommended for a rim speed up to 6000 feet per minute. The steel pulley also has the advantage of being 40 to 60 per cent lighter than cast iron for equal service. Unnecessary weight adds to fuel cost, loads up the shaft, increases the general friction in the hangers, and puts unnecessary stress on the hanger supports. Although for a single pulley the sum of these items may appear insignificant, the total saving where thousands of pulleys are used in a single shop will be considerable.

Since steel pulleys are generally split, whereas cast-iron pulleys are usually solid, the steel pulley has another advantage. If it is desired to place a solid cast-iron pulley on a line-shaft between several other pulleys, it is usually necessary to slip off a number of belts, remove a coupling, remove the shaft from the hangers, take off some of the pulleys, slip on the cast-iron pulley, replace the pulleys taken off, put the shaft back in the hangers, couple up, and put back the belts on all pulleys of the shaft section. The cost of doing this is often more than the first cost of a split steel pulley, which may be placed on the shaft directly without disturbing any of the other pulleys and without loss of time. Steel split pulleys also permit the use of interchangeable bushings. The bore of a pulley can be bushed down to fit any size of shaft below the size of the bore.

The set-screws generally used on cast-iron pulleys are another drawback. Much good shafting has been ruined by the ugly grooves cut in it by slipping set-screws. Shafting cannot stand much treatment of this kind and continue to give good service, because the grooves and small ridges scratched on the shafting in many cases make the removal of the pulleys very difficult. Split steel pulleys eliminate these troubles, for it is virtually impossible to cut up or seriously scratch a shaft with the bearing of a steel pulley.

The shrinkage of cast-iron pulleys at the time of casting is a source of much trouble, especially where the arms join the rim. The serious inner stresses commonly set up frequently cause cracking or weaken the pulley to such an extent that it breaks easily from slight jolts, or even from medium belt tension. It has been stated that more cast-iron pulleys are broken because of these internal stresses than from all other causes combined. Again, when a cast-iron pulley is heated by the friction of a creeping or slipping belt, the rim is bound to expand and the tension set up at the junction points may result in a fracture and the destruction of the pulley.

Tests have shown that both cast-iron and wood pulleys, when new, will hold a belt fairly well at light loads, but after use with normal or heavy loads they do not hold the belt nearly as well as pulleys with steel faces. Exhaustive tests by Prof. William M. Sawdon, of Cornell University, and by Messrs. Haven and Crosby, consulting engineers, of Boston, show that in the case of pulleys 18 inches by 12 inches, with a belt pull of 60 pounds per inch width of belt, a steel pulley slipped only 2.65 per cent, while a cast-iron pulley of the same size and operating under the same conditions had a belt slip of 5 per cent. In other words, there was a difference of 2.35 per cent in favor of the steel pulley. Another test gave the steel pulley a 2.7 per cent advantage. Where speeds are low, air resistance is of little importance, but countershaft pulleys and main drive pulleys often operate at speeds that make air resistance a factor, and in such cases the sharp steel pulley arm is another point in its favor.

On account of the uncertain characteristics of cast iron, the method of casting, and the fact that cast-iron pulleys must be machined before they can be used, it is usually necessary to balance them before they can be used on high-speed or relatively high-speed shafts. This is not necessary with the steel pulley, as steel is more homogeneous, and as the pulleys are made from sheet metal of uniform thickness, they are well balanced.

[1]Address: American Pulley Co., 4208-60 Wissahickon Ave., Philadelphia, Pa.

* * *

COMPOSITION OF HIGH-SPEED STEEL

In a paper read before the Steel Treating Research Society of Detroit, J. L. Thorne, of the Thorne Steel Treating Co., stated the following as the limits between which the various elements in high-speed steel are generally present: Carbon, 0.47 to 0.91 per cent; silicon, 0.12 to 5 per cent; manganese, 0.12 to 0.67 per cent; sulphur, 0.008 to 0.057 per cent; phosphorus, 0.006 to 0.051 per cent; chromium, 1.50 to 5.52 per cent; vanadium, 0.13 to 2.50 per cent; tungsten, 11.74 to 22.27 per cent. These figures are based upon samples analyzed in the laboratory of the Thorne Steel Treating Co.

For general purposes, the composition of high-speed steel which can be expected to give good all-around results when properly made and heat-treated is as follows: Carbon, 0.65 per cent; silicon, 0.12 per cent; manganese, 0.25 per cent; sulphur, 0.02 per cent; phosphorus, 0.02 per cent; chromium, 3.5 per cent; vanadium, 1 per cent; and tungsten, 18 per cent.

* * *

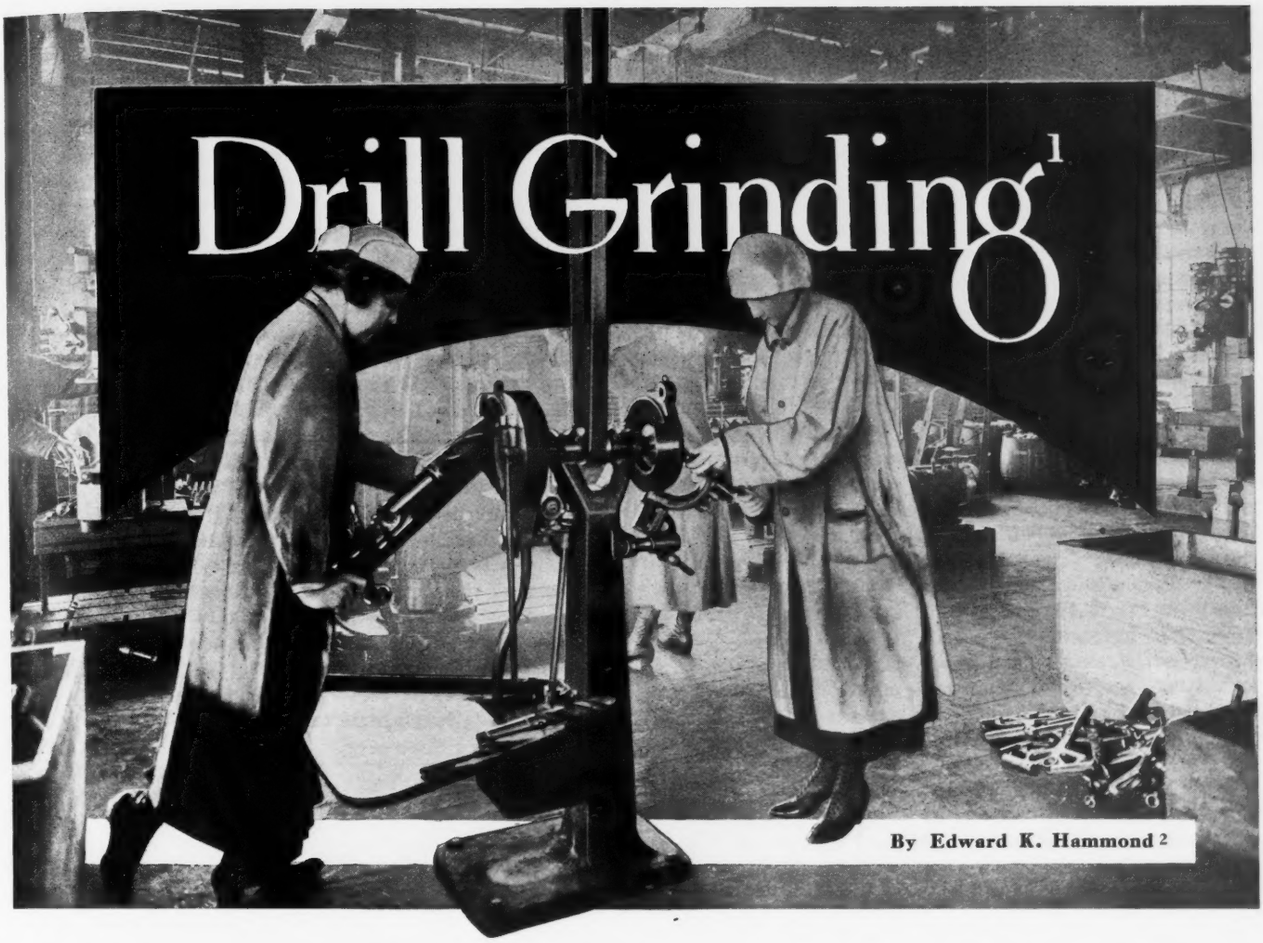
CALORIZED IRON AS AN ELEMENT FOR THERMO-COUPLES

Various thermo-couples, with iron as one of the elements, have high electromotive forces and are fairly constant when a temperature under 500 degrees C. is required. Above this point, iron oxidizes rapidly, thus reducing the force of the couple. "Calorizing," that is, producing a coating of aluminum alloy upon the surface of the metal, will prevent oxidation below 1000 degrees C., and, at the same time, will not materially affect the electromotive forces. Under test, calorized iron wire gives substantially the same thermo-electric potentials as uncalorized wire, is practically as constant, and has much longer life. Certain grades of wire, however, may require heat-treatment before this will be found to be true. This possibility and the degree of heat required should be determined by experiment.

* * *

Before the war Germany obtained most of her copper from the United States, taking over one-third of our exports. She had a large stock at the outbreak of hostilities, but this has been depleted long ago, and supplies are now coming from other countries. The Serbian copper mines are now being intensively exploited by the Germans and Austrians, and good copper deposits are also found in Poland. Germany, herself, also produces fair quantities of copper.

Drill Grinding[1]



By Edward K. Hammond[2]

IN order to give satisfactory service, a drill must be ground so that its point is of the correct form. Efficient results cannot be expected from a drill in which the material and original workmanship are of the required standard unless the subsequent work of grinding to keep the point of the drill in working condition is handled in such a way that the proper form is maintained. It is very difficult to grind a drill by hand and secure the desired results without spending too much time on the work; men employed in factories manufacturing drills learn to do this work very rapidly as the result of their special experience, but the drilling machine operator or tool-room attendant who attempts to grind a drill by hand is likely to fail to produce a point which comes even reasonably near to meeting all requirements. It is generally conceded that the form of a drill point exerts a powerful influence upon the rate of production, accuracy of drilled holes, and the number of holes which can be drilled between successive grindings. Granting this to be the case, it at once becomes apparent that steps should be taken to provide for grinding drills in such a way as to enable them to give the maximum amount of service.

Requirements in Drill Grinding

For the average shop, the only way to be sure of attaining such a result is to have the drills ground on special drill grinding machines which are so designed that they assure producing drill points that meet all requirements. These requirements are as follows: (1) Both cutting lips of a drill must be inclined at the same angle with the axis of the drill. (2) Both cutting lips must be of exactly the same length. (3) The drill point must have the proper lip clearance or contour of the surface back of the cutting edges, and this clearance must be the same for each side of the drill. All of these factors are of the utmost importance in enabling a drill to give satisfactory service. The various undesirable conditions which it is possible to produce through improper drill grinding are shown in Fig. 1. If both lips of the drill are not inclined at the same angle a with the axis, one lip will fail to counteract the tendency of the other to spring away from the cut. Furthermore, this will result in having one lip of the drill do more work than the other, with the result that this lip will soon become dull, and an abnormal torsional strain will also be set up. When the cutting lips of the drill have the same inclination to the axis but are of different lengths, it means that the point of the drill is off center, and as a result the hole will be cut over size by an amount equal to twice the eccentricity of the drill point. It is also possible to have an error in both the angle of drill point and equality of length of the lips of the drill, and where such a condition exists there will be a combination of the undesirable results which have been mentioned.

Concerning Angles of Drill Points

An angle of 59 degrees has been adopted as the standard angle for the points of twist drills, and such a point is well suited for drills engaged on all average classes of work. There are certain cases, however, where a modification of the form of the drill point is considered advisable. For instance, where a drill is fed down onto the surface of a piece of work held at an angle to it, and where no guide bushing is provided to hold the drill in the desired position, it will be found desirable to make the drill point to an angle more acute than 59 degrees in order to facilitate penetration of the drill point without tendency for it to slide down on the surface of the work. Conversely, a drill which is used to make holes in fairly thin tubing will give better results where the point is made blunter than that of a standard drill. The reason for this is that the feed pressure of the drill tends to spring the tubing slightly until the point of the drill starts to break through; then the work springs back quickly to its original position and increases the rate of feed—the condition being similar to that explained in connection with Fig. 7, which shows the result of spring in the members of a drilling machine—and such a condition may cause the drill to be broken.

[1] For information on drilling practice previously published in MACHINERY, see "Speeds and Feeds for Drilling," in the April number.

[2] Associate Editor of MACHINERY.

The two conditions which have been cited are typical of instances where it is necessary to reduce the standard angle when grinding drills. In general, if there is marked trouble through breakage of drills, and the other conditions which are likely to result in breakage are considered satisfactory, a slight modification of the drill point may produce a drill which gives the desired results without trouble from breaking. Another case where it is necessary to modify the standard form of twist drills is when drills are used for cutting brass. Here the standard angle of rake provided for use in drilling iron or steel is such that the drill would tend to hog into the work and produce an unsatisfactory condition of operation. To overcome this difficulty, it is the practice to grind the drill so that the rake angle is reduced practically to zero. Drills ground in this way will cut quite freely and give a satisfactory rate of production.

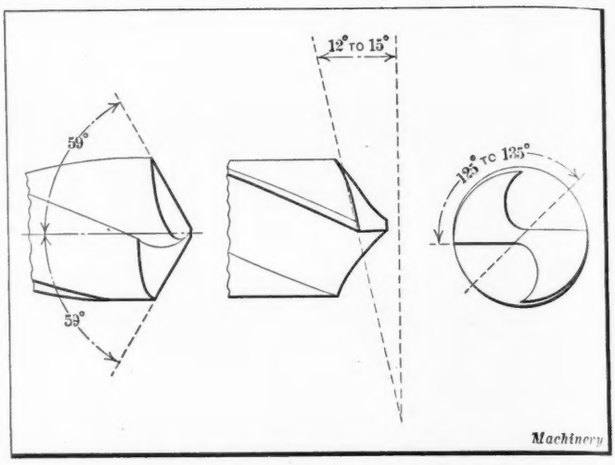


Fig. 3. Commercial Standards for Angle of Drill Point, Clearance, and Angle made by Chisel Point with Cutting Edges of Drill

Clearance behind Cutting Edges

In order that a drill may cut properly there must be the correct amount of clearance behind each of the cutting edges so that these edges may be forced down into the work. Where there is insufficient clearance a drill will not cut freely; and too much clearance results in weakening the tool at its cutting edges. Theoretically, the amount of clearance should be slightly in excess of that which is actually required for the rate of feed under which the drill is being operated, because any excess clearance results in a corresponding weakening of the cutting edge of the drill. As a matter of fact, drills are usually ground with an amount of clearance sufficient to take care of the maximum feed under which they are likely to be operated, and when so ground the amount that the cutting edges are weakened can safely be disregarded. In order to clearly understand the conditions which must be fulfilled in order to grind the desired amount of clearance on the point of a drill, it is necessary first to appreciate the fact that every point on each cutting edge is advanced on a spiral path as the drill is fed into the work. All of these spiral paths have the same lead—which is equal to the rate of feed per revolution—but each spiral has a different diameter.

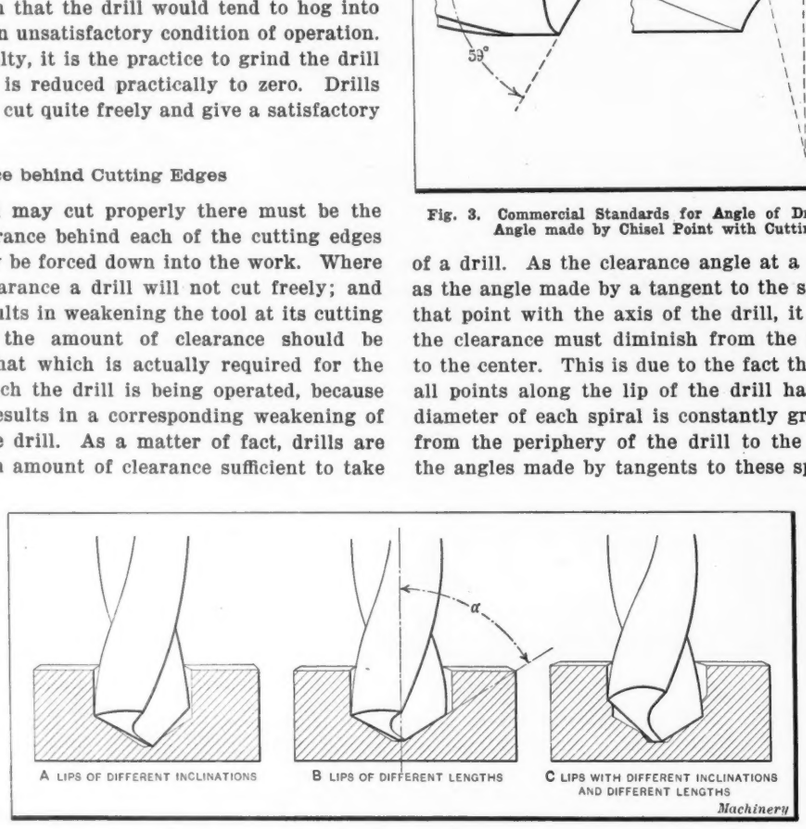

A LIPS OF DIFFERENT INCLINATIONS
B LIPS OF DIFFERENT LENGTHS
C LIPS WITH DIFFERENT INCLINATIONS AND DIFFERENT LENGTHS
Machinery

Fig. 1. Conditions under which a Twist Drill may be forced to operate through Incorrect Drill Grinding

The clearance angle is defined as the angle which a tangent to the spiral path followed by a point on the cutting edge at the periphery of the drill makes with the axis of the drill. This fact in regard to each point following its own spiral path will be readily understood by referring to Fig. 2; a study of this illustration will also show the requirements which must be fulfilled in order to grind the proper clearance on the point of a drill. As the clearance angle at a given point is defined as the angle made by a tangent to the spiral path followed by that point with the axis of the drill, it will be apparent that the clearance must diminish from the periphery of the drill to the center. This is due to the fact that while the spirals at all points along the lip of the drill have the same lead, the diameter of each spiral is constantly growing less as we pass from the periphery of the drill to the center. Consequently the angles made by tangents to these spirals with the axis of the drill will constantly decrease. In drills made by the Cleveland Twist Drill Co., the clearance angle at the periphery is from 12 to 15 degrees, and this angle decreases uniformly from the periphery to the center in such a way that the angle made by the chisel point with each cutting edge of the drill is from 125 to 135 degrees. This is the condition indicated in Fig. 3.

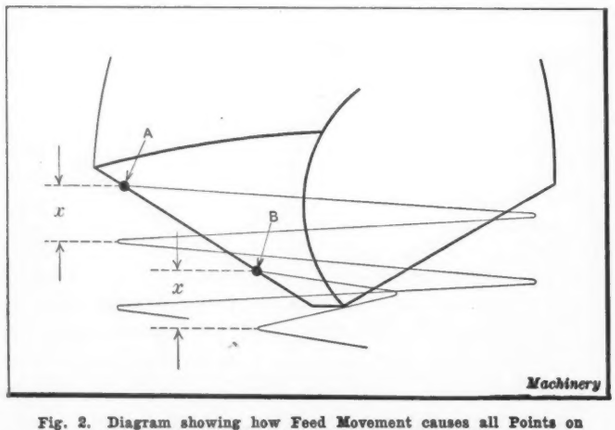


Fig. 2. Diagram showing how Feed Movement causes all Points on Cutting Edges of Drill to follow Spiral Paths of Same Pitch but of Different Diameters

In order to regulate the clearance so that it is correct for each lip of the drill all of the way from the periphery to the center, and to relieve each surface back of the cutting edges so that the proper degree of endurance and strength will be secured, it is necessary for the point of the drill to rock against the grinding wheel while it is being ground in a path similar to that which it follows while actually being fed into a piece of work. In order to secure this result, it is necessary to maintain the desired relation between the angle at which the drill is held against the grinding wheel and the axis about which it is rocked while in contact with the wheel. In Fig. 4, let *AB* in each diagram represent the axis about which the drill is rocked while being ground, and let *C* and *D* represent the radii of arcs through which different portions of the drill lip will be swung during the grinding operation. In order to have the clearance decrease from the periphery of the drill to the center, it is obvious that those portions near the center must travel on shorter paths and smaller circles than portions near the outer corner of the lip. In other words, radius *C* must be shorter than radius *D* in order to secure the desired clearance. It will be apparent that in the first two diagrams this condition is attained, while in the second two there is failure to secure the required condition.

Measuring or Gaging Drills after Grinding

In Fig. 5 are shown various methods of gaging twist drills after grinding in order to determine the accuracy of the point angle, the clearance, etc. At *A* is shown a simple gage made by the Standard Tool Co. for measuring the accuracy of the

59-degree point angle, and it will be seen that this gage is also graduated in such a way that it may be used to measure the length of the two cutting edges to see that these are equal. Used in the manner shown at *B*, this gage can also be employed to measure the center angle, i.e., the angle made by the chisel point with the cutting edges of the drill. Although the included angle of this gage is only 118 degrees and an angle of 130 degrees is required between the chisel point and cutting edges of the drill, the use of the gage in this way enables a very close estimate to be made of the accuracy of the angle of the chisel point, and it will be recalled that this angle determines the clearance provided for the cutting edges.

At *C* is shown how a protractor may be used to measure the point angle, and this illustration is self-explanatory. Another method of measuring the angle of the drill point is shown at *D*, and this method also affords a means of obtaining an idea of the accuracy of the clearance provided behind the cutting edges. The length of each cutting edge is first measured with the scale to see that they are equal; and if so, the drill is supported as shown and measurements are made at each side, as indicated in the illustration. If these measurements are equal, it shows that the point angle is the same at both sides of the drill. This method may also be used to measure the clearance provided for each cutting edge by placing the drill point beside the scale as shown, and then slowly revolving the drill. If the clearance at each side is not the same, it will be indicated by a difference in the relative positions of the drill and scale for corresponding positions of the drill. It must be borne in mind that this method indicates the clearance provided at the heel of the drill only, and while this clearance may be correct, there may still be a serious error in clearance near the drill point. At *E* and *F* are shown two types of gages made by the Morse Twist Drill & Machine Co. for testing the angle of drill point; these illustrations show clearly the method of using the gages without requiring a description.

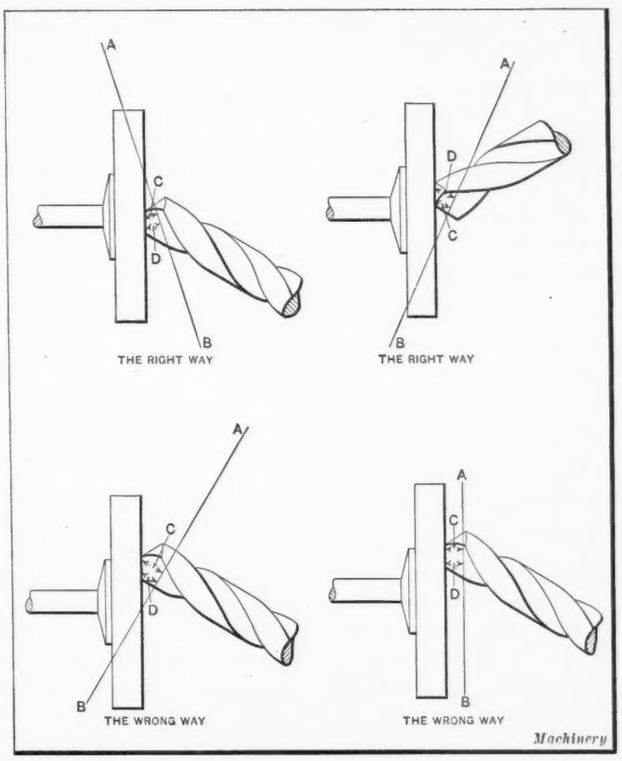


Fig. 4. Diagram showing Correct and Incorrect Methods of holding Drill Point against Wheel while grinding

Use of Drill Grinding Machines

There are a number of drill grinding machines on the market which are properly designed to provide for accurately securing the required contour for the drill point. Drills ground on such machines ought to meet all of the requirements to which attention has been called. It should scarcely be necessary to call attention to the fact that it is very important for the drill grinding machine to be kept in proper adjustment in order to produce the expected results, but we were recently told of one shop which purchased its twist drills from a well-know manufacturing firm, and an investigation made to determine the cause of breakage of drills for which a replacement claim had been made revealed the fact that the drill grinding machine used in this shop was so badly out of adjustment that it failed to produce drill points of the required form. When attention was called to the fact that the broken drills had been improperly ground, the possibility of such a condition was promptly denied, as it was asserted that "they had been sharpened on a drill grinder." Subsequently this machine was properly adjusted and a responsible mechanic was employed to do all of the drill grinding, and since that time there has been a marked falling off in the number of drills broken in the shop. Several manufacturers of twist drills who have had a great deal of experience with troubles which may result through improper grinding state that in shops using any considerable number of drills the wages of an experienced mechanic, placed in charge of all drill grinding and held responsible for the results obtained, would be more than paid by the saving in broken drills.

How to Grind a Drill by Hand

It is a difficult matter to grind a drill by hand and secure the desired results without taking altogether too much time in performing the grinding operation, as previously mentioned. Nevertheless, the mechanic who makes an intelligent study of the requirements of drill grinding can learn to grind a drill by hand after he has had enough experience to enable him to acquire the necessary degree of dexterity. One method of grinding drills by hand, which is capable of giving satisfactory results, is to hold first one lip of the drill and then the other against the grinding wheel so that a flat clearance surface is ground at the back of each cutting edge. In doing this work great care should be taken not to change the angle which the chisel point of the drill makes with the cutting edges, as it is the angle of the chisel point which determines the amount of clearance provided for the cutting edges. After these flat clearance surfaces have been ground, the mechanic very carefully swings the drill back and forth so that the flat ground surfaces are blended into the remainder of the surface back of each cutting edge. This method of grinding will not produce a drill point which appears to approximate closely the form produced on a drill grinding machine, but the results obtained with a drill ground in this way will often be far more satisfactory than those resulting from the use of a drill ground by hand, where the mechanic has attempted to secure a closer approximation of the original form of the drill point through swinging the drill back and forth on the surface of the grinding wheel.

If the mechanic attempts to grind a drill by hand and duplicate the movement secured through the use of a drill grinding machine, the proper method of procedure is as follows: The drill is held between the thumb and index finger of the left hand at a short distance back of the point, and the hand is steadied by the tool-rest of the tool grinder. The drill is held at such an angle to the grinding wheel that the surface of the drill point rests flat against the wheel, and great care must be taken to have the chisel point of the drill in a vertical position; in other words, the cutting edge of the drill is inclined upward. With the drill held in this position, the mechanic grips the shank between the thumb and index finger of his right hand and slowly oscillates the drill about an imaginary axis, between the thumb and index finger of his left hand, taking care to keep the chisel point vertical at all times. After grinding one side of the drill in this way, the drill is turned over so that the other side may be ground. This method can be used with extremely satisfactory results by men who have had a great deal of experience in drill grinding, but it is probable that the average mechanic will secure better results through the method of hand grinding referred to in the preceding paragraph. In any case, hand grinding is not recommended for the average shop, as the superior speed

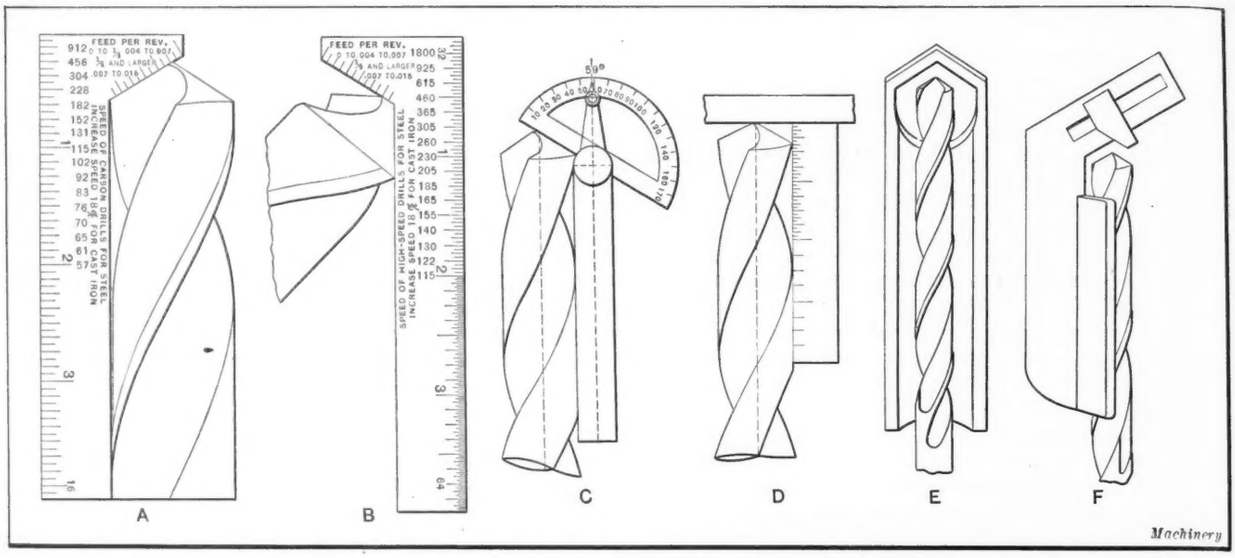


Fig. 5. Methods of measuring Angle of Drill Point, Angle made by Chisel Point with Cutting Edges and Clearance behind Cutting Edges

and quality of workmanship obtained through the use of drills ground on a drill grinding machine are quite sufficient to warrant the investment in an equipment of this kind.

Effect of Improper Drill Grinding

A better idea of the actual effect of improper drill grinding will be gathered by reference to Fig. 6, which shows various conditions of the drill point which are made possible through correct or incorrect grinding. At *A* is shown a drill ground with the proper clearance for the cutting edges, and at *B* is shown a drill on which an insufficient amount of clearance has been furnished at the center, although there is plenty of clearance at the heel of each cutting edge. It will be recalled that the angle of the chisel point, i.e., the line separating the two faces of the drill point, indicates the amount of clearance provided for the cutting edges, and at *C* is shown what is likely to happen to a drill where the angle of the chisel point and clearance of the cutting edges are insufficient. This drill had plenty of clearance at the heel, but very little clearance at the center, with the result that it was split up the center. A better idea of the way in which the angle of the chisel point indicates the amount of clearance will be gathered by referring to the two end views of the drill shown at *D* and *E*. At *D* is shown a drill in which the chisel point has been ground to make an angle of 130 degrees to the cutting edges, which gives a sufficient amount of clearance, while at *E* the angle formed is only 100 degrees, and this drill has insufficient clearance.

Most twist drills are made in such a way that the web at the center increases in thickness as the length of the drill is gradually decreased in sharpening. On account of this increase in web thickness, mechanics have acquired the practice of grinding away the web at the drill point or "thinning" the web, as the process is commonly called. A great deal of trouble is likely to result from this practice of thinning the drill point, due to the excessive amount of metal which is often ground away. Where skilled mechanics do the work and are careful to grind away only a sufficient amount of metal to maintain the web thickness equal to the original thickness of the web at the point of the drill when it was new, this practice is not detrimental; but if an excessive amount of grinding is done, it is almost sure to produce undesirable results. At *F* is shown a drill point in which the web has been properly thinned to reduce it to the original dimension, while at *G* is shown a drill point on which thinning has been carried to excess. A drill ground in this way is extremely liable to break through splitting up the center, and such a drill will also require more power to drive it, due to trouble experienced in clearing the chips. While provision of the necessary amount of clearance for the cutting edges of a drill is highly important, it is equally important not to provide too much clearance, because in such cases an insufficient amount of metal is left behind the cutting edges and trouble is likely to be experienced through chipping the drill. At *H* is shown a drill on which the proper amount of clearance has been provided, while at *I*

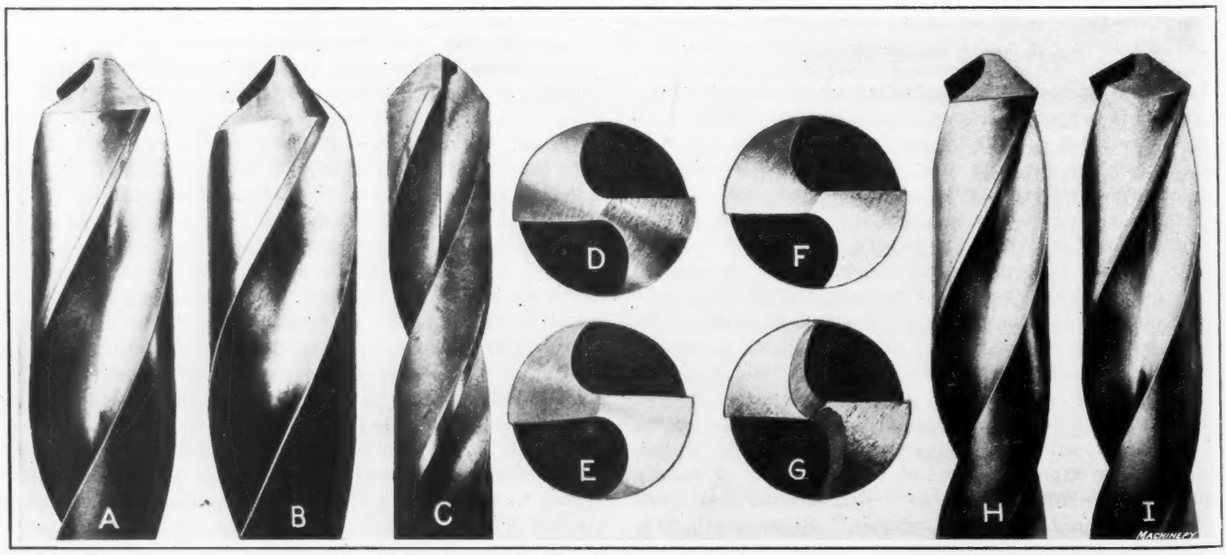


Fig. 6. (A) Drill with Proper Clearance. (B) Drill with Insufficient Clearance at Center. (C) Drill split because of Insufficient Clearance and Incorrect Angle between Chisel Point and Cutting Edges. (D) End of Drill with Chisel Point making Correct Angle with Cutting Edges. (E) End of Drill with Chisel Point making Incorrect Angle with Cutting Edges. (F) End of Drill where Web has been properly thinned. (G) End of Drill where Thinning has been carried to Excess. (H) Drill with Proper Clearance. (I) Drill with Excessive Clearance, which weakens Cutting Edges

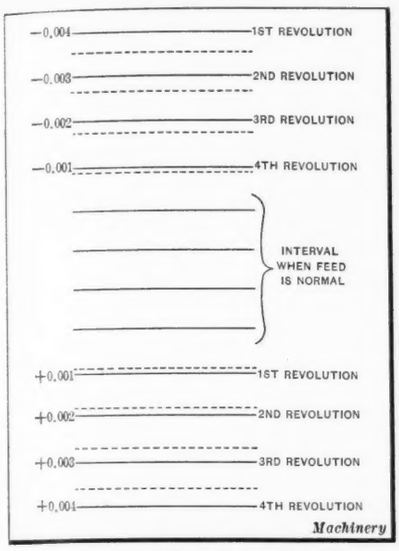


Fig. 7. Diagram showing how Spring in Drilling Machine causes Excessive Rate of Feed, which may break Drill

the drill is ground away to provide excessive clearance, which has weakened the edges so that they are liable to chip and make the drill give very unsatisfactory results in operation.

Causes of Broken Drills

The conditions of service under which a twist drill operates are more severe than those imposed upon almost any other type of cutting tool, because the drill must of necessity be of such size that it can enter the hole in which it works, while its cross-section has to be greatly reduced in order to provide the required clearance for the escape of chips. Despite this fact, it is quite probable that the average twist drill receives as little consideration as any tool used in the machine shop, there being a somewhat general impression among mechanics that a twist drill is sold ready for use and can properly be expected to continue to give satisfactory service regardless of the way in which it is handled. The fallacy of this idea is clearly shown by the tremendous wastage which occurs every year through breaking drills as a result of improper use. Reference has already been made to the conditions that must be fulfilled in order for a drill to give efficient service, and if the grinding operation is not conducted so that these conditions are fulfilled, an abnormal strain is likely to be placed upon the drill which may rapidly assume sufficient proportions to cause it to be broken.

There is another point which is likely to be responsible for breaking of drills, namely, the spring and lost motion in drilling machines due to improper design. The way in which this condition is likely to cause breakage of drills will be understood by reference to Fig. 7. For the sake of discussion, we will assume that the members of a drilling machine can be sprung 0.010 inch as a result of back-pressure exerted by the drill while in operation. During the time that this spring is being imposed upon the machine members, the rate at which the drill point is fed into the work is represented by the normal feed per revolution *minus* the amount of spring imposed upon the members of the drilling machine per revolution.

When this lost motion has been taken up, the drill will continue to operate at the normal rate of feed until such a time as the drill point breaks through the work at the bottom of the hole. When this result takes place there will be a sudden reduction of back-pressure exerted by the drill, with the result that the strained members of the drilling machine will suddenly react; now, under these conditions, the rate of feed will be the normal rate provided by the gearing in the feed-box *plus* the increase due to a sudden release of the strain on members of the drilling machine. This sudden increase in the rate of feed as the drill breaks through is the reason why so many drills are broken at just this point, and not because there is any tendency for the bottom surface of the work to catch the cutting lips of the drill according to a somewhat general impression which exists among mechanics who have given very little thought to the situation.

Now, in the case of a drilling machine where the parts have not been designed in a way which assures the required degree of rigidity, it is obvious that one of two conditions must exist: either the rate of feed must be made the maximum safe rate for the drill *minus* the amount of additional feed imposed upon the drill during the time that it is breaking through the hole at the bottom of the work, or else the risk must be run of breaking a number of drills through this sudden increase in the rate of feed while the operation is being finished. Obviously, the decision of any experienced production manager will be that neither condition will meet his requirements. He will insist upon the purchase of drilling machines of sufficiently rigid construction so that the amount of back-pressure exerted by the drill point while penetrating the work will not be sufficient to cause an appreciable amount of spring.

Determination of Magnitude of Feed Pressure and Torsion

In connection with research work conducted by engineers of the Cleveland Twist Drill Co. to determine the magnitude of strains imposed upon a twist drill due to feed pressure and torsional resistance, a special drilling machine was constructed in such a way that the table of the machine rests upon a piston-rod connected to a piston entering a cylinder filled with oil. When a drill mounted in the spindle of this machine is driven into a piece of work supported on the table, it will be obvious that pressure exerted by the drill results in introducing a corresponding amount of pressure on the piston, and hence on the oil contained in the cylinder. A recording pressure-gage connected to this cylinder makes it possible to calculate the amount of pressure exerted by the drill while penetrating the work. To prevent rotation of the table of this special drilling machine, a radial arm is carried out from the table and provided with a piston-rod connecting with a piston in a second oil cylinder. A recording pressure-gage is also connected to this cylinder, by means of which it is possible to measure the torsional stress upon the drill.

Fig. 8 shows a combined feed-pressure and torsion chart for a 1¼-inch drill operated in this machine, and this chart illustrates very clearly another important consideration in preventing broken drills as a result of spring in the drilling machine members to which reference was made in a preceding paragraph. This is the provision of a proper amount of clearance on the drill surfaces behind the cutting edges. Reference to this pressure-torque chart will make it apparent that there is a pronounced difference in feed pressure and torsion for each of the pairs of curves recorded on this chart. These differences in feed pressure and torsion are due to the fact that the drill used in making one pair of curves, where the feed pressure and torsion are greater, was ground on a machine which provides less clearance for the drill point than is the case on the drill grinding machine which ground the drill used in drawing the pair of curves where feed pressure and torsion are less. Obviously, this lays emphasis upon the importance of grinding drills on a machine which will provide the required amount of clearance to enable satisfactory operation to be secured under the maximum amount of feed that will be used under the most severe conditions of operation,

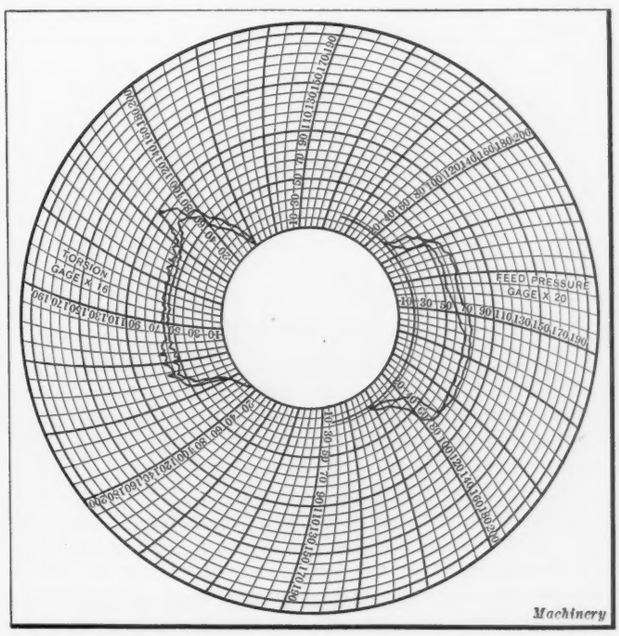


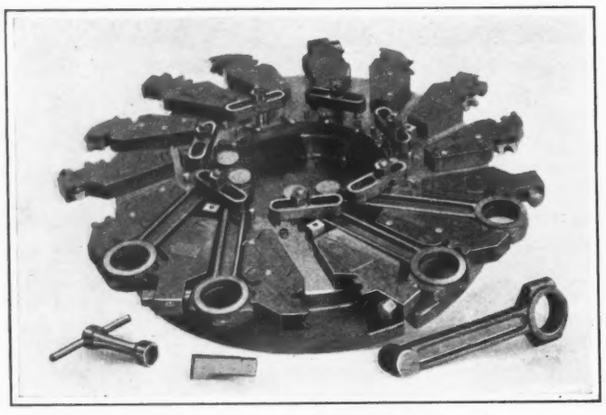
Fig. 8. Combined Torsion and Feed-pressure Chart for 1¼-inch Drill operated in Special Testing Machine which registers Torsion and Feed Pressure on Recording Hydraulic Pressure Gages

without unduly increasing the pressure and consequent spring in the drilling machine. In this connection the reader's attention is directed to the paragraph on drill grinding which explains methods of measuring the amount of clearance provided on the drill point to make sure that this conforms with the recommendations of firms specializing in the manufacture of drills. In the case of the feed-pressure curves in the chart, it will be seen that the pressure first runs up rapidly and then takes a peculiar drop before assuming the normal condition. This drop is due to the fact that near the center of the drill, the cutting edges have practically no rake; the pressure runs up while the point of the drill is entering the work, and when approaching the periphery, where there is a considerable amount of rake, this rake helps to pull the drill into the work, thus reducing the feed pressure and producing the peculiar dip seen in the feed-pressure curves.

* * *

CONTINUOUS MILLING FIXTURE

The accompanying illustration shows a continuous milling fixture made by the Becker Milling Machine Co., Hyde Park, Boston, Mass., which is employed for the milling of the connecting-rods for the Liberty motor on a double-spindle Becker vertical milling machine. Four surfaces on the rods are milled at once, the top and bottom surfaces at each end being milled simultaneously. The main spindle, which is provided with two cutters, one for the upper and one for the lower surface, mills the outer end of the rod, while the auxiliary spindle with cutters mounted in a similar manner mills the inside end of the rods. Fourteen connecting-rods are mounted in the fixture at a time, and as the fixture rotates on the table, the finished rods are taken out and new rods are inserted by the operator while the work progresses. Every other jaw for holding the connecting-rods is fixed, while every alternate jaw is pivoted at one end. By clamping against one rod with a clamping screw at the extreme end of the pivoted clamp, pressure is brought to bear upon the ends of the connecting-rods on each side of the pivoted clamp, thus making the clamping very rapid. At the inside end, one clamp also holds two rods in place. This clamp is provided with a small pin which fits into a slot in the clamping stud, so that, when tightened, the clamp must always be in one position and cannot come out far enough to interfere with the milling cutters.



Continuous Milling Fixture for Liberty Motor Connecting-rods

* * *

An agreement has been reached by representatives of the piano manufacturers and the War Industries Board by which a curtailment of 30 per cent of the output will be made. Meanwhile the War Industries Board will arrange for the transfer of war work to the musical instrument factories wherever possible. It is probable that the curtailment plan will be extended to all building activities and the industries manufacturing building materials that are needed for war work. The brewing, window glass, and boxboard industries already have made voluntary agreements to reduce production from 30 to 50 per cent, and it is understood that restrictions suggested for the automobile industry are to be enforced.

CENSUS REPORT OF MACHINE TOOL INDUSTRY

According to a partial report of the 1914 Census of Manufactures, which has just been published, there were in that year, in the United States, 409 establishments making machine tools and 277 establishments making other metal-working machinery. The machine tools manufactured that year were valued at $31,446,660, and the other metal-working machinery at $17,419,526. Ohio was the leading state in the production of machine tools, with products constituting over one-fourth of the total reported for all states. Rhode Island ranked second, Connecticut third, and Massachusetts fourth. In the manufacture of other metal-working machinery, Pennsylvania was the leading state in the value of output, with New York ranking second, Ohio third, and Connecticut fourth. The four states combined contributed nearly three-fourths of the total value of products. The output, according to states, is given in the table.

VALUE OF METAL-WORKING MACHINERY MANUFACTURED IN 1914

State	Value of Machine Tools	Value of Other Metal-working Machinery
Ohio	$9,014,178	$2,909,389
Rhode Island	3,679,190	174,490
Connecticut	3,280,940	2,407,987
Massachusetts	3,042,894	859,608
Pennsylvania	2,466,198	4,069,278
Illinois	1,935,861	1,902,651
New York	1,782,494	3,160,369
New Jersey	1,558,412	546,346
Michigan	1,179,761	280,564
Wisconsin	1,004,812	209,052
All other states	2,501,920	899,792

Machinery

* * *

BRANCH GAGE LABORATORY OF THE BUREAU OF STANDARDS

The Bureau of Standards has announced that a branch gage laboratory has been established in New York City. This laboratory was opened and prepared to receive gages for test on April 15. It is located on the sixth floor of the Engineering Societies Building, 29 W. 39th St., New York City, where it is easily accessible both from the Pennsylvania and the Grand Central stations. The object of the laboratory is to take care of gage testing in the New York district, but all gages which are ordered by the War Department for test at the Bureau of Standards at Washington should be submitted directly to the Bureau of Standards in Washington.

The branch laboratory, however, has facilities for testing all types of munition limit gages, and the equipment installed is practically a duplication of the various machines and devices used by the Bureau of Standards in Washington for testing plain plug and ring gages, profile and other forms of gages, especially screw-thread gages. The facilities of this branch laboratory are available, without charge, to manufacturers carrying out government contracts for munitions of war. Gages may be submitted by mail, express, or by messenger. It is recommended that they be sent by registered or insured mail rather than by express, on account of the saving of time. Firms submitting gages for test are requested to furnish complete information as to the identification and classification of the gages, instructions for test and shipment, and information as to the drawings and specifications which establish the important dimensions of the gages submitted. If copies of the Ordnance Office drawings or other government gage drawings or part drawings are submitted with the gages, it will greatly facilitate the test and permit the sealing of the gages.

* * *

According to an estimate made by the National League of Women's Service, 1,266,000 women at the beginning of this year were employed on work directly or indirectly necessary for the carrying on of the war. Of this number, 100,000 were employed in the munitions factories.

LETTERS ON PRACTICAL SUBJECTS

WE PAY ONLY FOR ARTICLES PUBLISHED EXCLUSIVELY IN MACHINERY

CORRECTING ERRORS IN PRECISION SCREW-CUTTING LATHE

It is a well-known fact that the lead-screws on ordinary lathes, such as are used for general manufacturing operations, are not accurate enough for such work as making thread gages,

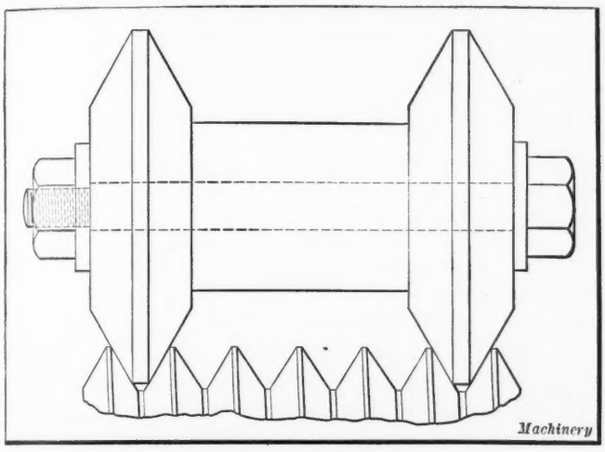


Fig. 1. Gage for testing Lead of Thread

and they have to be either corrected or replaced. The lead-screws are usually a little short in lead and a thread cut on an ordinary lathe is likely to be slightly "drunken" or irregular because of such inperfections as play in the spindle or inaccuracy in the gearing. While these errors may be slight, they can readily be detected by precision testing methods.

In examining a lathe to be used for precision screw cutting, all radial and end-thrust bearings from the headstock down to the lead-screw should be carefully gone over and corrected, if necessary. Any endwise movement of the main spindle or lead-screw is, of course, particularly objectionable. It is also essential to correct any errors there may be in the gearing. For instance, the bushing that carries the intermediate gear may be from 0.005 to 0.007 inch eccentric, in which case it should be replaced by a new one. The gear teeth must also be accurate, both as regards evenness of spacing and concentricity.

After correcting the parts referred to or replacing them with new ones if necessary, the lathe must be provided with an accurate lead-screw. In order to illustrate the method of procedure, we shall assume that the screw is 0.0005 inch short per inch and the problem is to produce a new lead-screw of the correct lead. In order to do this, the taper attachment is used to compensate for the error in the original lead-screw while cutting a new one. If the lathe is intended for such work as threading plug gages, a short master screw can be used. Obviously, the length of screw that can be cut while held between the centers of the lathe in the usual manner is limited; therefore a comparatively short screw is cut and this master screw is connected to shafting as shown in the upper part of Fig. 3, so that the length will suit the lathe. It is first necessary to determine to what angle the taper attachment should be set. Since the original lead-screw on the lathe is short 0.0005 inch per inch or 0.006 inch per foot, the cosine of the angle to which the taper attachment should be set equals $\frac{11.994}{12} = 0.9995$. Referring to a table of cosines, we find that 0.9995 is the cosine of 1 degree 49 minutes, which is the amount the attachment is inclined from its parallel position. The master screw blank is next set parallel with the taper attachment by traversing an indicator along it. A follow-rest should be used even if the screw is only 30 inches long, and this should be clamped to the independent slide which connects with the taper attachment. The driving end of the dog should have a ball-shaped end and the faceplate slot should be made as square as possible on account of the rocking motion of the dog in driving the part when held at an angle. As it is difficult to make perfect gearing, there should be as few gears as possible between the lathe spindle and the lead-screw.

In order to test the accuracy of the lathe before cutting the master screw, it should be used for cutting a trial thread on

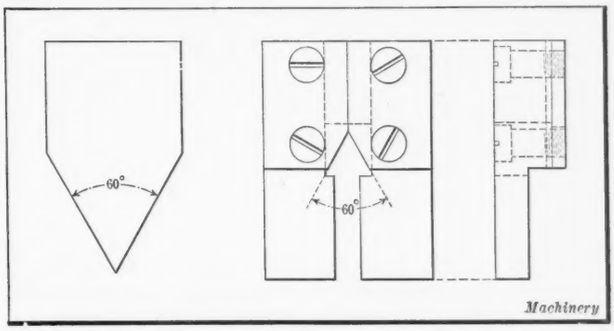


Fig. 2. Sixty-degree Angle Gages

a short plug. A plug about 6 inches long, 1½ inch in diameter, having 10 threads to the inch will be found convenient for measuring. Fig. 1 illustrates the type of gage used for testing the accuracy of the thread. This gage consists of two disks, a spacing collar, and a bolt for holding the parts together. In order to insure accurate angles for this gage, 60-degree male and female gages of the form shown in Fig. 2 are used. The

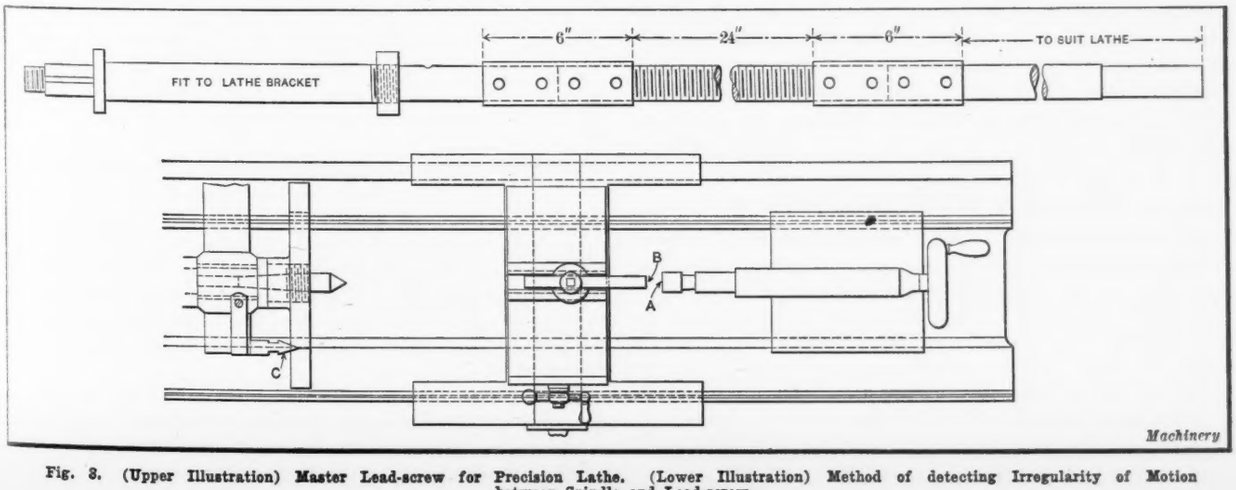


Fig. 3. (Upper Illustration) Master Lead-screw for Precision Lathe. (Lower Illustration) Method of detecting Irregularity of Motion between Spindle and Lead-screw

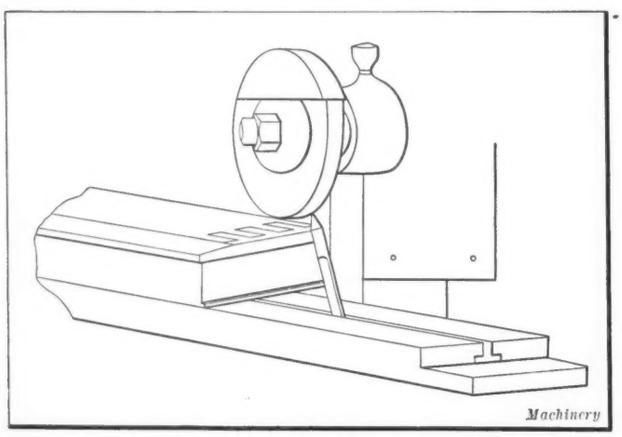
sine-bar and Johansson gages are used in connection with this work in order to reduce the error to a minimum. If the center-to-center distance between the disks of the gage shown in Fig. 1 measures exactly 1 inch as closely as can be determined, no light should be visible between the gage and the screw when applied as shown in the illustration.

The next test is to determine whether the lathe cuts an even thread or one that is irregular or "drunken." The method of making this test is illustrated in Fig. 3. A plug *A* having a smooth and true end is fitted to the tailstock spindle and a piece having a flat end *B* is clamped on the toolpost. These end surfaces *A* and *B* should be parallel. A large faceplate is mounted on the spindle, and two lines are located on it 180 degrees apart. The lathe is geared to cut, say, ten threads per inch, and the pointer at *C* is used to indicate half revolutions. Each time the spindle is turned a half revolution, the distance between surfaces *A* and *B* is measured by using Johansson gages. If the errors in the lathe have been eliminated, the movement for each half revolution should equal 0.050 inch. In manufacturing thread gages, it is advisable to use the master screw-cutting lathe only for making other lead-screws; otherwise its accuracy will soon be impaired as a result of wear.

Beloit, Wis. J. E. LINDGREN

TRUING AN EMERY WHEEL QUICKLY

When truing an emery wheel on a surface grinder provided with a magnetic chuck, it is customary to clamp the diamond holder in the vise or in a special fixture. However, the vise



Quick and Easy Method of truing an Emery Wheel

may be in use on another machine, or the spindle of the grinder may have been lowered so that the wheel is so near the magnetic chuck that a vise could not be used to hold the diamond holder without raising and again lowering the spindle. By the following method no vise or fixture is needed to hold the diamond holder in truing a straight wheel. The holder is milled on the sides until its thickness is 1/32 inch less than the width of the bolt slot, in which it is placed so as to lean against the magnetic chuck at an angle of about 15 degrees, as illustrated. It is then held firmly to one side with the right hand. The spindle is lowered until the diamond touches the wheel, and, using the left hand to turn the handle, the diamond is traversed across the face of the wheel. This method, of course, is not recommended for large wheels.

New York City E. J. HIGGINS

MILLING A RIFLE GAGE

It might be of interest to many employed in rifle factories to know the methods used by one large munitions plant in

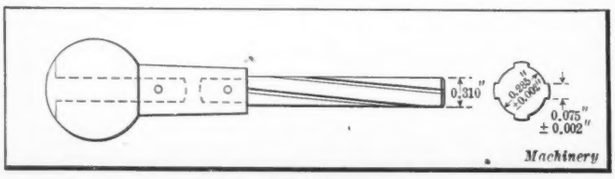
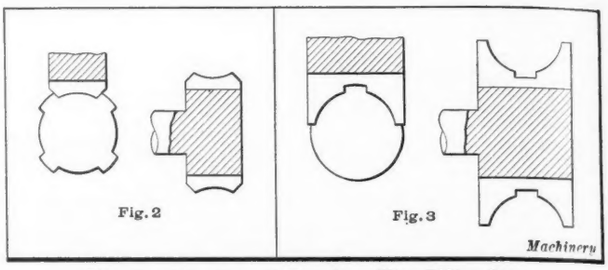


Fig. 1. Rifle Plug Gage



Figs. 2 and 3. Form Cutters for milling Rifling Gage

milling the gage shown in Fig. 1. The first method was to straddle-mill each lug to width and depth and then machine to the proper diameter between the lugs with a small end-mill. In this way it was possible to produce about three gages in eight hours. Later, a form cutter like that shown in Fig. 2 was made. With this, four cuts completed the gage, so that an apprentice boy could produce three gages an hour. But this output is doubled when the form cutter shown in Fig. 3 is used. The radius is backed off 6 degrees; then when the table is set at 6 degrees, which is the angle of the spiral, the cutting edge of the radius is at an angle of 90 degrees with the 0.285 inch diameter of the gage. By this method one-half of the gage is finished in one cut, as shown; the machine is indexed twenty turns, or half way around, and the gage is finished by the second cut.

Bridgeport, Conn. GEORGE W. COOK

LOSS DUE TO NOT MOVING PARTS PROMPTLY

It is very important that all work in a factory or machine shop be moved promptly from place to place as the different operations, including inspection, painting, and assembling, are completed. This prompt movement prevents any possible lag between operations and encourages the operators to work as quickly as possible, for it will convince them that there is a real need for their output. Such promptness will have a better effect on the average workman than the word "Rush" marked on the order, regardless of the size of type or lettering or the color of ink or pencil used. Nothing will take real interest out of a man quicker than to have his work lie around after he has finished it. In cases where the movement between operations is dependent on the individual operators or departments, it is much better to have those finishing their parts make the deliveries rather than have those who are to do the next work go after them.

Watervliet, N. Y. MARTIN H. BALL

AIR-RIFLE BRACE

In Fig. 1 is shown the brace used in an air rifle, and in Fig. 2 are shown three views of the two-stage follow-die for making it in one operation. The finished piece is shown at *A*, Fig. 1, and at *B* is shown the strip from which it is made, with the

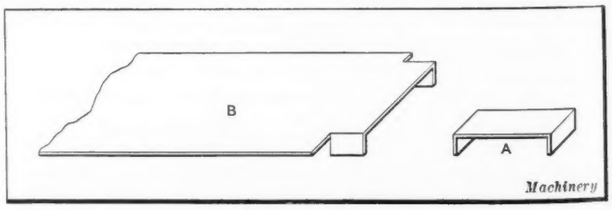


Fig. 1. Air-rifle Brace

legs bent down. The usual method of making a piece of this shape is to use metal the width of the piece, cut out scrap to the cut-off, and form the piece on top of the die. This necessitates some waste and is slow, as the piece must drop from or be knocked off the die. Sometimes the piece is pushed through the forming die, which is a much faster process, but does not give good square bends.

In the die shown in Fig. 2 the piece is formed across the strip, cut off without waste, and pushed through the die, and as the motion is very short, the strip can be fed into a press making 125 to 150 strokes a minute with no trouble. As the

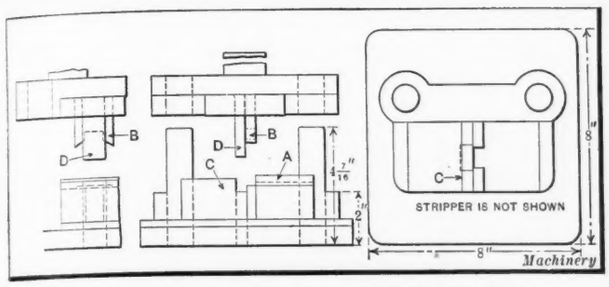


Fig. 2. Two-stage Follow-die for forming Air-rifle Brace

edges are sheared, the brace is not quite so smooth as if made the other way, but the corners are square and sharp, and tumbling smooths it. The operation is simple. The strip is fed through the stripper *A*, Fig. 2, under the punch *B*, which shears and turns down the legs. The punch bottoms the piece on the die and so squares the corners. On the up stroke, the strip is moved forward to the solid stop *C*, so that on the next down stroke the first piece is cut off and pushed through by the punch *D*, which is backed by stop *C* while punch *B* is forming the next brace.

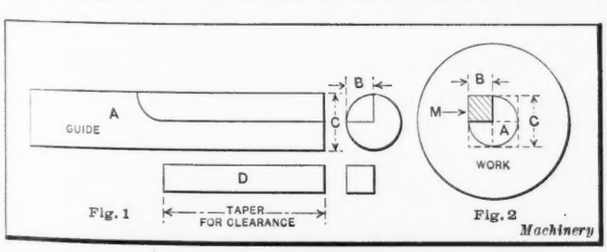
Plymouth, Mich. W. B. GREENLEAF

GEARS TO CUT THREAD OF 4.5-MILLIMETER PITCH

An operator wanted to cut a thread of 4.5-millimeter pitch on a lathe that had a lead-screw having five threads to the inch and a fixed gear on the stud having twice as many teeth as the gear on the spindle with which it meshed. As there are 25.4 millimeters in one inch, there were $25.4 \div 4.5 = 5.644$ threads to the inch to be cut. As the lead-screw has five threads to the inch and is geared 2 to 1, the ratio of the gears desired is $\frac{10}{5.64}$. Setting the slide-rule to $\frac{10}{5.64}$, it is found that among the whole numbers that coincide, the ratios $\frac{62}{35}$, $\frac{55}{31}$, and $\frac{48}{27}$ come very close to the requirements. By having several sets of numbers to choose from, gears that will fit the conditions may easily be found, and one or more gears may be on hand that can be used. J. C. S.

BROACHING SQUARE HOLES

Figs. 1 and 2 show a method the writer recently used for rough-broaching a hole 1/2 inch square in a piece of tool steel, enough stock being left to finish with a sizing broach. A piece of 1/2-inch, round, cold-drawn steel that was a little more than twice the length of the piece to be broached was used as a pilot; from this a quarter section was milled as shown. A piece *D* of Armstrong self-hardening steel, one-third



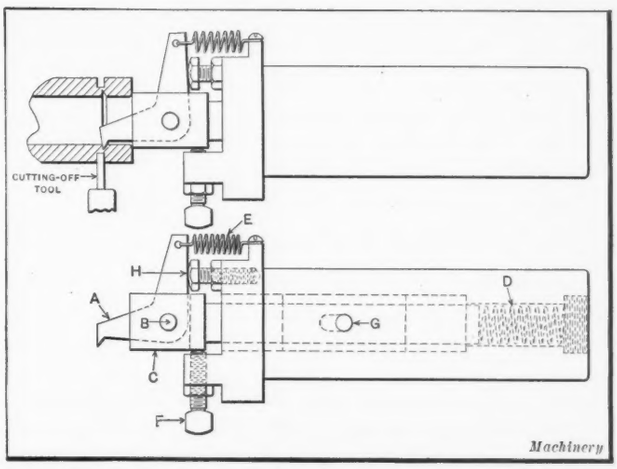
Figs. 1 and 2. Broaching Square Holes

longer than the work, was used for the broach; this was given a slight taper and was left from 0.004 to 0.005 inch under size at the larger end. The pilot piece *A* was then inserted in the hole, and the broach *D* was inserted in the quarter section *M* and forced through in the arbor press. Piece *A* was then turned a quarter turn, gaging by the eye, and the operation repeated on the other three corners, as shown by the dotted lines in Fig. 2. The hole was then broached to size with a multiple-tooth sizing broach. The piece to be broached by this method should be cut 1/8 or 3/16 inch longer than the finished size, as the first operation has a tendency to break out the corners on the opposite side. This can be avoided, however, by using a double-cut broach of 3/16 and 1/4 inch size or by using two pieces.

Bremerton, Wash. STANLEY EDWARDS

CHAMFERING TOOL

When collars or similar parts are cut from bar stock or tubing, the inner edge which is left sharp is sometimes removed by a second chamfering operation. The tool shown in the accompanying illustration is designed to chamfer the inner edge of work of this class before the part is completely cut off from the bar or tube. This tool is held in the turret and it is arranged to feed the cutter inward automatically for forming a beveled surface opposite the end of the piece being severed by the cutting-off tool. The upper view shows the tool in operation, and the lower view illustrates its construction. The cutter *A* is pivoted on pin *B* which is carried by a rod or holder *C*. This rod is normally held outward by a spring *D* and the cutter *A* is also drawn backward by spring *E*, so that the end clears the work as the tool advances. The set-screw *F* bears against the end of holder *C* and serves to steady it. The pin *G*, which passes through an elongated slot in holder *C*, limits the travel of the latter. The chamfering tool is so located relative to the work that the end of holder *C* comes into contact with the end of the collar or other part that is being cut off, thus causing the holder to move back-



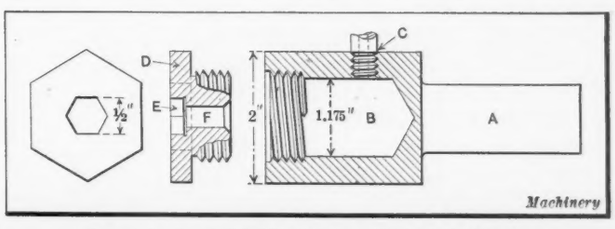
Tool used to chamfer Inner Edges of Collars before they are cut off from Bar or Tube

ward against the tension of spring *D*. When the extension on cutter *A* comes into engagement with the adjustable screw *H*, the cutting end is forced into engagement with the work and forms a groove as indicated by the upper illustration. The groove is in such a position that it forms a beveled surface for the inner edge of the collar after the latter is cut from the bar. This tool makes it unnecessary to place collars or similar parts in a speed lathe for removing the sharp edge by using a hand scraper, which is the method that is frequently employed.

Flint, Mich. C. C. SPREEN

TAPPING STUD NUTS IN SCREW MACHINE

Tapping nuts in a hand screw machine seems to be an odd thing to do, when tapping machines are made for just this purpose; but quite a few shops are not equipped with these machines. Some of these use drilling machines, but the writer



Fixture for tapping Stud Nuts in a Hand Screw Machine

has seen nuts tapped with the fixture shown in the accompanying illustration. This fixture is connected directly to the oil-pump, and the oil passing through the nut keeps the tap clear of chips and the tap from breaking. The fixture is made from a piece of 2-inch cold-drawn steel. The shank *A* is turned to fit the hole in the turret of the machine, and then the piece is turned around and held in a three-jaw chuck while the hole, or oil chamber *B*, is bored; at the end, a 1¼-inch, 14 U. S. thread per inch is cut for the reducer *D*. A hole *C* is then drilled in the large part of the holder, to serve as the oil inlet. This hole is tapped with a standard ¼-inch iron-pipe tap and a short nipple is inserted. A small valve attached to this nipple regulates the flow of oil, the other side of the valve being connected to the oil-pump by a flexible metal tube.

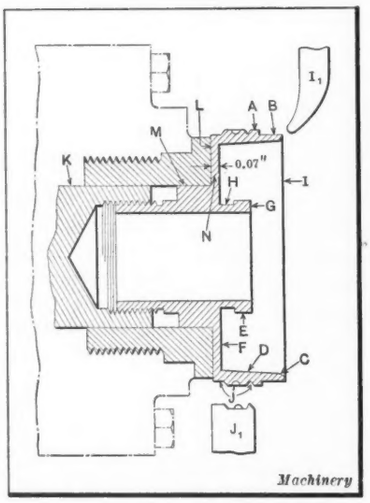


Fig. 1. Azimuth Circle of Panoramic Sight

The reducer *D* is made of a piece of 2-inch hexagonal cold-drawn steel. After the recess and the thread have been cut, the small hexagonal hole *E* is broached a little larger than the outside diameter of the nut to be tapped, and the hole *F* is drilled about 1/16 inch larger than the outside diameter of the tap to be used. This tap is held in a regular spring collet in the spindle, as the operator is then able to remove the nuts already tapped from the shank of the tap without stopping the machine. When being tapped, the nuts are set in the broached hole *E* and held there with the operator's finger until they are brought into contact with the tap. If the nut is not held in this way, the oil flowing from the oil chamber will force it out. All parts, with the exception of the pipe connections, are casehardened. Care must be taken when broaching the hole *E* to see that no burrs are left to tilt the nut when tapping.

Aurora, Ill. JOHN J. BORKENHAGEN

MACHINING PANORAMIC SIGHT PARTS

When setting up a turret lathe for a job, the problem of tooling should be given careful study. The number of pieces to be made largely governs the cost of the tools provided. Standard tools should be used whenever possible, but time should not be sacrificed in order to use standard tools if the number of pieces to be made will warrant special tooling. Where there is a large variety of work in small quantities, standard tools will generally handle the work to the best advantage, and when a large number of similar pieces are to be machined, the use of special tools or a combination of standard and special tools will probably be the best and cheapest method of handling the operation. The work should be held securely, even if special jaws or fixtures are necessary.

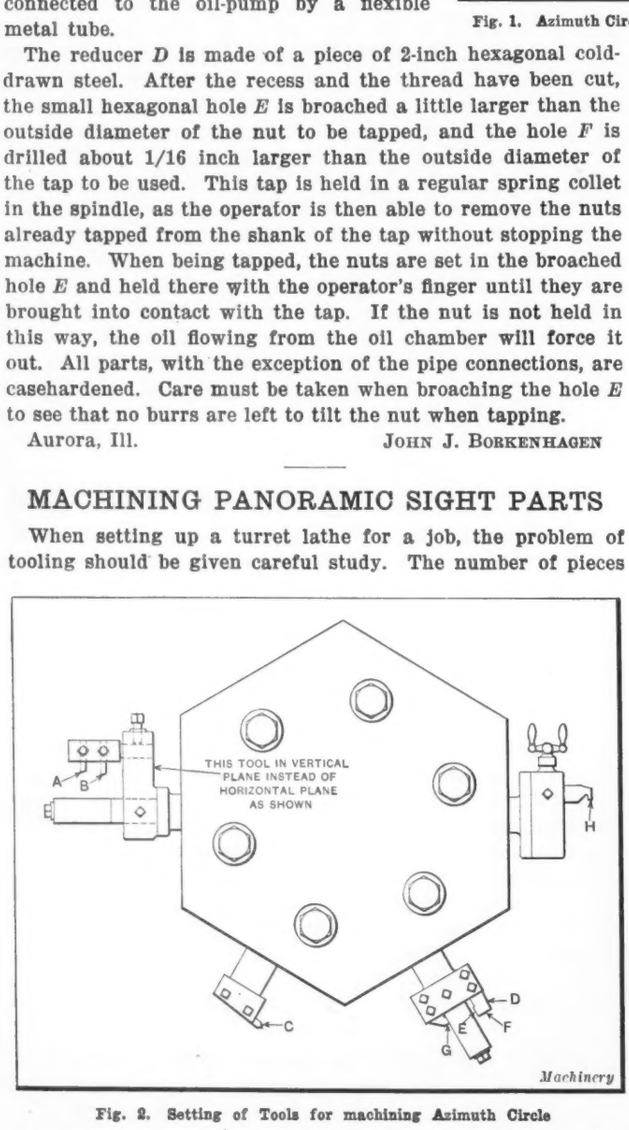


Fig. 2. Setting of Tools for machining Azimuth Circle

The azimuth circle for the panoramic sight used by the United States Army is made from a forged steel bar, roughed out to shape and annealed. The part is then mounted on a Warner & Swasey No. 4 turret lathe as shown in Fig. 1. As will be seen, it is held in an adjustable hood and a threaded draw-back adapter *L*. In order to insert the piece in the machine, the plunger *K* is pulled back and the piece is then screwed in until it bears against adapter face *L*, which gives it a good support. Bearing *M* holds the piece true. The surfaces that were finished on this machine are marked by reference letters. Surfaces *I* and *J* were finished by tools I_1 and J_1, respectively, which were held in the cross-slide.

Fig. 2 shows the setting of tools for the machining operations, the reference letters of the tools corresponding with the reference letters of the finished surfaces in Fig. 1. The face *L*, which is only 0.07 inch thick, remained straight until the tools *D*, *E*, *F* and *G* had completed their cuts, when it was found that face *L* was convex, due to the burnishing action of these tools. It may be thought that this was caused by stresses produced by roughing out the cold-rolled stock on the screw machine, but as the work was annealed previous to the finishing operations, no such stresses remained. It was decided to change the tooling to single-point tools as far as possible, and this resulted in overcoming the trouble. The new tooling is illustrated in Fig. 3. With this method of tooling it was possible to face surface *F* and bore *D* with single-point tools, thus eliminating the burnishing action of a forming tool and the tendency of the piece to screw up tight in the plunger *K*. The latter action would not interfere with the removal of the work, because the plunger is thrown forward, but it might have a tendency to spring the face *L*, although the adapter appears to give a shearing action at *N*.

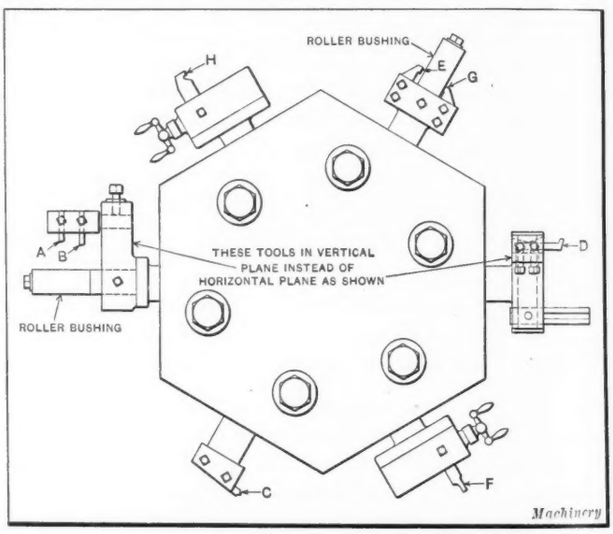


Fig. 3. Improved Setting of Tools for machining Azimuth Circle

At *A*, Fig. 4, is shown a brass worm bearing cap for use in the panoramic sight, and at *B* is shown a cheap and satisfactory tool for forming the seat in piece *A*. The tool was hardened and ground all over. As it does not have much of a cutting edge, it probably would not cut steel, but it worked successfully on brass.

Cleveland, Ohio L. J. ORR

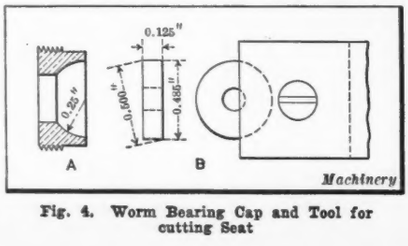
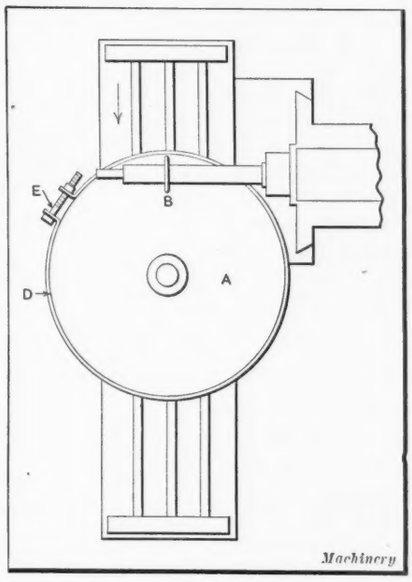


Fig. 4. Worm Bearing Cap and Tool for cutting Seat

CUTTING A LONG RACK

Having a long rack to cut, the writer was obliged to resort to the following method: As shown in the accompanying illustration, the index head was placed on the milling machine table with the spindle vertical, and a large faceplate *A* was secured to the spindle. A band *D* was placed around the faceplate and drawn up snug with the bolt *E*, the band projecting above the faceplate a distance equal to the depth of the tooth. The cutter *B* was then started from the inside and cut out through the band like a crown gear. The band was afterward straightened on the anvil and several thicknesses were riveted together, making a good rack. As the index was set for a gear having a diameter equal to the diameter of the faceplate, one thickness of the band made the tooth a shade too wide on the outside and a shade too thin on the inside.

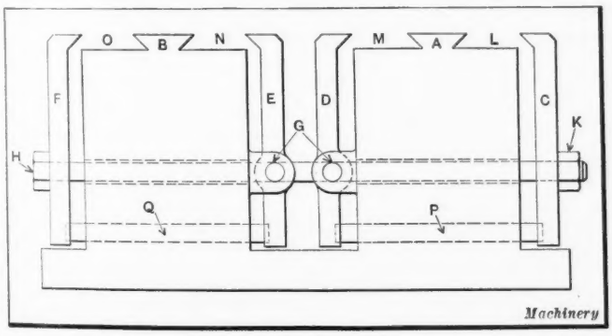
Thompson, Iowa E. E. LARSON



Cutting a Long Rack

MILLING FIXTURE

The accompanying illustration shows a fixture for a milling machine with two fixed jaws *A* and *B*, and movable jaws *C*, *D*, *E*, and *F*, *D* and *E* being hinged at *G*. In operation, work is placed at *L*, *M*, *N* and *O*, and is clamped by means of a star-wheel or a nut at *K*, which through bolt *H* draws the jaws together. The bolt should have a clearance in the fixture and through the clamps *D* and *E*. The clamps *C* and *F* are supported at the lower end by the rods *P* and *Q*, which press against the lower ends of *D* and *E* when the nut *K* is tightened. The rods should be a working fit in the fixture and a tight fit in the clamps *C* and *F*, but a loose fit in the clamps *D* and *E*. Clamps *D* and *E* should be made heavy enough at the center to allow for a clearance hole for the draw-bolt and pins. The jaws may be modified to hold odd-shaped pieces of work; this particular device was used to hold four pieces six inches long, across the machine, and they were held as tight as one piece would have been.



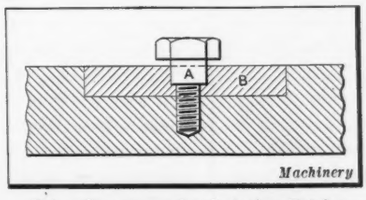
Milling Fixture for clamping Four Pieces simultaneously

Indianapolis, Ind. ROBERT W. SMITH

KINK FOR FASTENING PATCHES SECURELY

The accompanying illustration shows an easy method of fastening patches in place. All that is necessary is to turn down the head of the cap-screw *A* to fit the counterbore of the patch *B* and then shape or file the screw flush with the patch. The cap-screw will then hold the patch securely in place.

Milwaukee, Wis. FRED FRUHNER

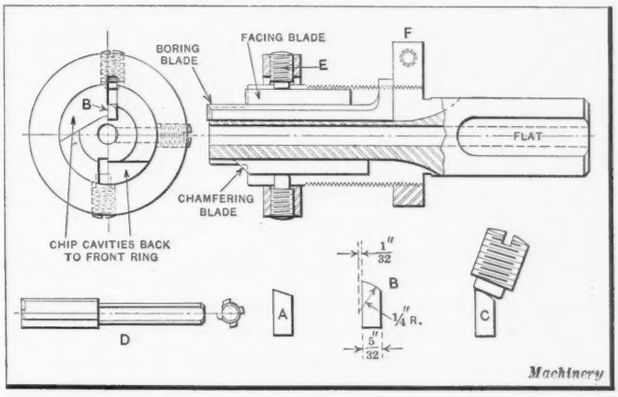


Using Cap-screws for fastening Patches

BUILT-UP TOOLS FOR BRASS WORK

While the use of built-up tools in manufacturing work is quite general, there are comparatively few shops where any sort of system of interchangeable blades, collars of standard design, etc., is used. These are important points to consider in connection with this class of tools, as they save time and material in building, time in designing, and time in the shop when it becomes necessary to replace a worn-out blade. The type of tool shown in the accompanying illustration is especially suitable for use in a turret lathe for machining brass parts. The body is preferably made of tool steel, hardened, and the shank ground, as the extra cost of this material over machine steel will more than be made up in the increased length of life and freedom from repairs due to dents in the shank, battered threads, etc. The collars may be of machine steel.

Boring blades in tools of this kind usually have a straight relief, as shown at *A*, and it will be readily seen that an angle which is correct for one diameter will interfere on a smaller diameter and have insufficient backing for a larger diameter. The eccentric relief shown at *B* does not have these disadvantages. The radius given is correct for a blade 5/32 inch thick, and the radius for any other thickness of blade should be in proportion, the center from which the arc is struck being kept 1/32 inch ahead of the face of the blade in all cases. When a blade is designed for a new tool, a record should be kept and consulted whenever another built-up tool is designed. In the majority of cases, after a list of reasonable length is compiled, it will be found that a blade has already been made which can be used in the contemplated tool, by milling the slots to the correct depth. This makes it possible to carry a comparatively small stock of blades and at the same time furnish any built-up tool of this design with a new blade. Experience with these blades shows that it pays to grind the top and bottom after hardening, as they warp more or less, and the accuracy of the hole drilled depends upon the blade being the proper height and lying flat on the bottom of the slot. A special fixture is required to grind eccentric relief.



Tools for machining Brass in Turret Lathe

Most boring blades require a ring *F* behind them as shown, because the set-screw *E* in the front ring cannot always be depended upon to prevent pushing back. This will sometimes make two screw rings necessary where two boring blades are used. When the set-screws in the front ring are used to clamp directly on an eccentric relief, the screw should be set at an angle, as shown in detail at *C*, to prevent damage to the edge. Headless or hollow set-screws are preferred, as square heads

break off frequently. A hole in the center of the body as shown is often necessary to hold the shank of a small fluted or flat drill, or in some cases a twist drill. When the smallest diameter to be bored by a blade is so small that it is impossible to mill a slot of sufficient depth with a bottom in the body of the tool, a flat may be milled on the shank of the small drill, as shown at *D*, and the blade slot milled through into the center hole, allowing the blade to rest on the small shank and act as a clamp for it. In most cases, each diameter of the body part of the tool should be 1/16 inch smaller than the corresponding boring diameter.

Dubuque, Iowa — CHESTER W. HATHAWAY

BURNISHING TOOL FOR BABBITT BUSHINGS

The following article describes a burnishing tool that is used to burnish the babbitt bushings of automobile and marine engine connecting-rods, etc. The bushings are die-castings and the metal is coarse-grained and not solidly compressed, so that when the engine is in operation the continued blows of the connecting-rod would compress the metal and the result would be a loose bearing. The hole of the bushing could be made smooth and sized by the use of a reamer, straight arbor or mandrel, but these tools would not remedy the condition mentioned, and for this reason a burnishing tool is used which

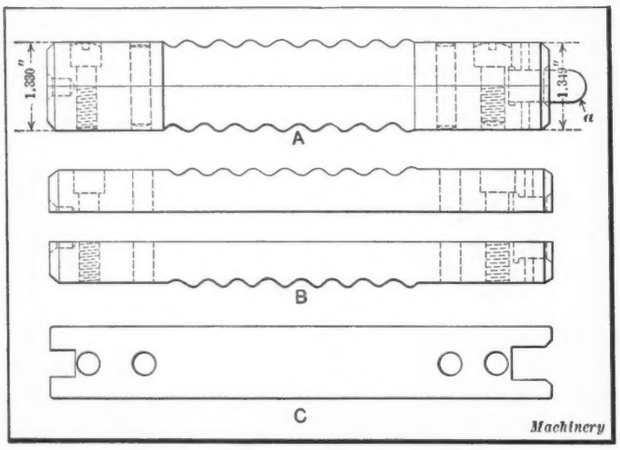


Fig. 1. Burnishing Tool for Connecting-rod Bushings

compresses and forces the babbitt metal into any irregular surfaces that there may be in the bore of the connecting-rod, thus giving a bearing, the only change in size of which will be due to friction.

In making the burnishing tool which is shown at *A*, Fig. 1, the two pieces of material were bolted together and rough-turned as shown at *B*. Shim *C* was then placed between the two parts and the hole bored for pilot *a*. The two pieces *B* were then carburized and hardened, and the flat surfaces ground, after which they were bolted together without the shim and the outside diameters ground. The shim was again placed between the two pieces and the hole for *a* was ground.

The connecting-rod that the burnishing tool is used on is illustrated in Fig. 2. In Fig. 3 the connecting-rod is shown mounted on the machine for the burnishing operation. At *A*

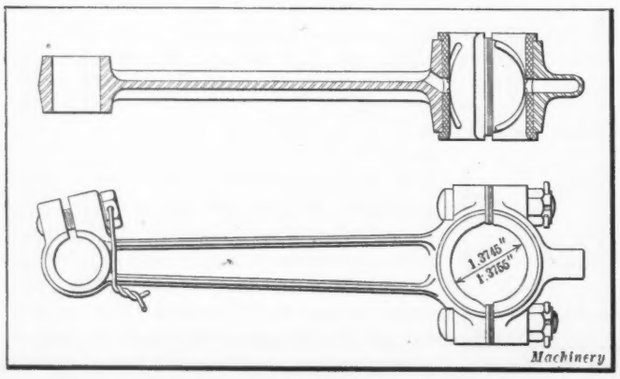


Fig. 2. Connecting-rod burnished by Method described

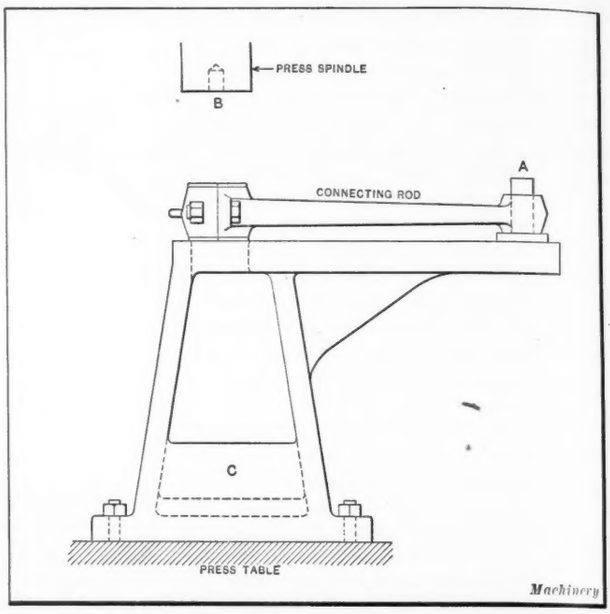


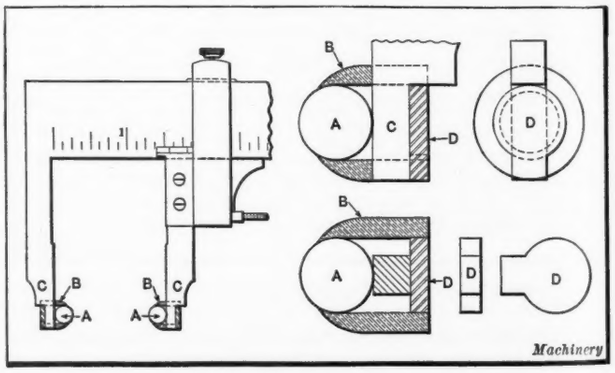
Fig. 3. Connecting-rod mounted for Burnishing Operation

is a pin for locating the connecting-rod. The burnishing tool is secured at *B*, the pilot *a*, Fig. 1, fitting into the hole of the press spindle. The tool is pressed through the connecting-rod bushing, and it then drops into the pocket *C*, which is partly filled with lead so that the end of the burnishing tool will not be marred.

Flint, Mich. — C. C. SPREEN

BALL-POINT HOLDER FOR CALIPER SQUARE

Several improvised ball-point attachments for large caliper squares and vernier calipers were made some time ago in a certain shop in the Middle West, on account of inability to secure satisfactory deliveries on some measuring tools. Most of the tools were for measuring distances between large holes and other concave surfaces. The ball-point attachment illustrated served so well that it was used eventually on a wider scope of work. The steel balls *A* are ¼ inch in diameter and



Ball-point Holder for Caliper Square

are a running fit in the brass sleeve *B*, which is slotted at one end to receive snugly the caliper jaw *C*. The steel section *D* at the end is soldered in place and partly closes the outer side of one slot. After this piece *D* has been soldered in place, and before the attachment has been placed on the vernier caliper jaw, a piece of steel 0.001 inch larger than the thickness of the jaw *C* is inserted. This piece is used only while assembling the ball and sleeve so as not to injure the jaw. Then the ball *A* is inserted in the sleeve and made to rest on this piece of steel. The rounded end of the sleeve is then carefully calked against the ball, using a concave punch for this operation, after which the piece of steel is removed. The attachment will be found to fit snugly when placed on the caliper jaw.

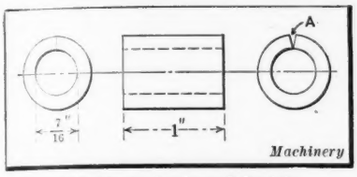
New York City — E. J. HIGGINS

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

DIE FOR FORMING THIMBLE

F. M. H.—In the accompanying illustration is shown a thimble 1 inch long, made from No. 10 gage strip band iron, with a 7/16-inch hole that should be as nearly round as possible. Can a die be made to form this thimble in one operation; if not, how many operations will be required? Will some reader of MACHINERY suggest a die that will form this thimble without leaving an opening as shown at *A*?



Thimble to be formed by Die

PROBLEM IN GEOMETRY

A. B. C.—Prove that in any triangle the product of two sides is equal to the product of the diameter of the circumscribed circle and the altitude upon the third side.

Answered by Robert W. Smith, Indianapolis, Ind.

Let *ABD* be the triangle and *AE* the altitude; draw *AC* through center *O* of the circumscribed circle and connect the points *C* and *D*. Then *AEB* is a right angle by construction, and *ADC* is a right angle by being measured by an arc of 180 degrees. Also, angles *ABD* and *ACD* are similar because they are measured by the same arc *AD*; therefore, the right triangles *ABE* and *ACD* are similar. As a result, $AB : AC = AE : AD$; or $AB \times AD = AC \times AE$.

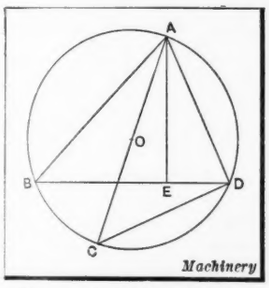


Diagram illustrating Problem in Geometry

THE LOWENHERZ THREAD

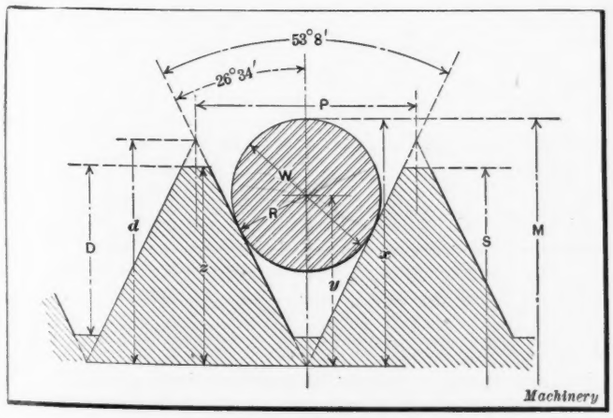
W. S.—What are the proportions of the Löwenherz thread and how can a formula be deduced for determining what the micrometer reading should be for a given screw diameter, when measuring the thread by the three-wire system?

A.—The Löwenherz thread (a section of which is shown in the accompanying illustration) has flats at the top and bottom the same as the U. S. standard form, but the angle is 53 degrees 8 minutes. The depth *D* equals 0.75*P*, and the vertical distance *d* between the points where the sides at the root and top would intersect if continued (as indicated by the dotted lines) is equal to the pitch *P*. The width of the flats at the top and bottom is equal to 0.125*P*. This screw thread is based on the metric system (see table) and is used extensively for the fine threads of measuring instruments and to some extent in shell manufacture. Assuming that *M* equals the micrometer reading and *S* the outside diameter of the screw, then $M = S - 2z + 2x$; $z = 0.875P$, and $2z = 1.750P$; $x = y + R = R + \frac{R}{\sin 26 \text{ deg. } 34 \text{ min.}}$, or $x = R + \frac{R}{0.44724}$. $2x = 2\left(R + \frac{R}{0.44724}\right) = 2B + \frac{2R}{0.44724} = \frac{2.89448R}{0.44724} = 6.4718R = 3.2359W$.

Hence:

$$M = S - 1.75P + 3.2359W$$

This formula, expressed as a rule, would be as follows: To determine the micrometer reading for a Löwenherz screw thread of given diameter, multiply the pitch of the thread by the constant 1.75; subtract the result from the outside diameter of the screw and add to the difference 3.2359 times the diameter of the measuring wires.



The Lowenherz Thread

LOWENHERZ THREAD

Diameter		Pitch, Millimeters	Approximate Number of Threads per Inch	Root Diameter, Millimeters	Width of Flat, Inches
Millimeters	Inches				
1.0	0.0394	0.25	101.6	0.625	0.0012
1.2	0.0472	0.25	101.6	0.825	0.0012
1.4	0.0551	0.30	84.7	0.950	0.0015
1.7	0.0669	0.35	72.6	1.175	0.0017
2.0	0.0787	0.40	63.5	1.400	0.0020
2.3	0.0905	0.40	63.5	1.700	0.0020
2.6	0.1024	0.45	56.4	1.925	0.0022
3.0	0.1181	0.50	50.8	2.250	0.0025
3.5	0.1378	0.60	42.3	2.600	0.0029
4.0	0.1575	0.70	36.3	2.950	0.0034
4.5	0.1772	0.75	33.9	3.375	0.0037
5.0	0.1968	0.80	31.7	3.800	0.0039
5.5	0.2165	0.90	28.2	4.150	0.0044
6.0	0.2362	1.00	25.4	4.500	0.0049
7.0	0.2756	1.10	23.1	5.350	0.0054
8.0	0.3150	1.20	21.1	6.200	0.0059
9.0	0.3543	1.30	19.5	7.050	0.0064
10.0	0.3937	1.40	18.1	7.900	0.0069
12.0	0.4724	1.60	15.9	9.600	0.0079
14.0	0.5512	1.80	14.1	11.300	0.0089
16.0	0.6299	2.00	12.7	13.000	0.0098
18.0	0.7087	2.20	11.5	14.700	0.0108
20.0	0.7874	2.40	10.6	16.400	0.0118
22.0	0.8661	2.80	9.1	17.800	0.0138
24.0	0.9450	2.80	9.1	19.800	0.0138
26.0	1.0236	3.20	7.9	21.200	0.0157
28.0	1.1024	3.20	7.9	23.200	0.0157
30.0	1.1811	3.60	7.1	24.600	0.0177
32.0	1.2599	3.60	7.1	26.600	0.0177
36.0	1.4173	4.00	6.4	30.000	0.0200
40.0	1.5748	4.40	5.7	33.300	0.0219

Machinery

A TOOLMAKER'S PROBLEM

A. S.—I am a toolmaker with but slight knowledge of mathematics. The following problem came up recently in connection with my work, which I am unable to solve. Please show me how to find *x* to the nearest thousandths of an inch.

Answered by J. J. Clark, Scranton, Pa.

A.—An elementary knowledge of geometry, trigonometry, and algebra is required in order to solve this problem. Although a formula could be derived that would apply to the case, a knowledge of how to use a table of trigonometric functions is necessary, and it is also necessary to be able to solve an affected quadratic equation.

Referring to the illustration, the first step is to find the angle $A'DF = \phi$. $B'H = 1.853 + 0.200 = 2.053$, and $HD = B'H \cot \phi = 2.053 \cot \phi$. $A'B'O' = \phi$, and $O'B' = FH = 1.2 \operatorname{cosec} \phi$. Therefore $FH + HD = FD$, or $1.2 \operatorname{cosec} \phi$

$+ 2.053 \cot \phi = 2.38$. Since $\text{cosec } \phi = \sqrt{1 + \cot^2\phi}$, $1.2\sqrt{1 + \cot^2\phi} + 2.053 \cot \phi = 2.38$; from which, $1.2\sqrt{1 + \cot^2\phi} = 2.38 - 2.053 \cot \phi$. Squaring both sides of this equation, $1.44 + 1.44 \cot^2\phi = 5.6644 - 9.77228 \cot \phi + 4.214809 \cot^2\phi$. Transposing and combining terms, $2.774809 \cot^2\phi - 9.77228 \cot \phi + 4.2244 = 0$. Solving this quadratic equation, $\cot \phi = 0.50458$ or 3.01721; hence, $\phi = 63$ degrees 13 minutes 32 seconds, or 18 degrees 20 minutes 13 seconds. There are evidently two values for the angle, since from a point without a circle two tangents may be drawn to the circle. In other

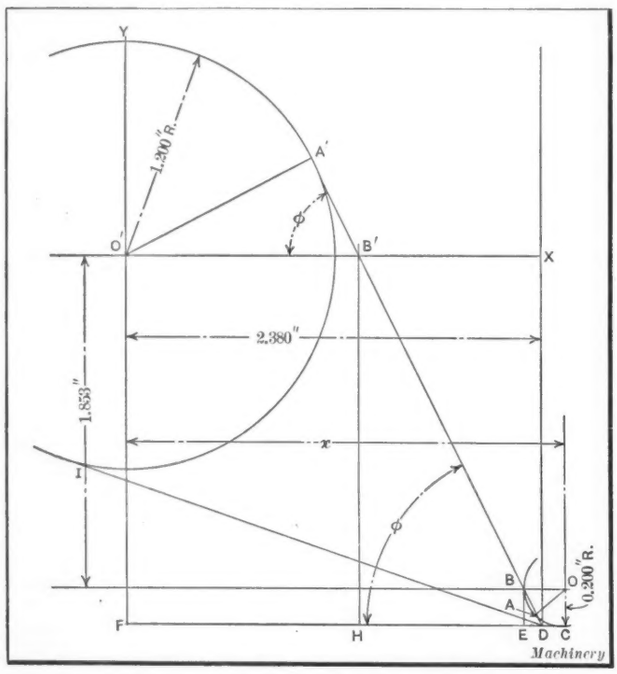


Diagram illustrating Solution of Toolmaker's Problem

words, the angle may be $A'DF$ or IDF. In the present case, the larger angle is the one required, and $\phi = 63$ degrees 13 minutes 32 seconds. The angle $ABO = AOC = BDE = \phi$. $ED = BE \cot \phi = 0.2 \cot \phi$. $BO = OA \text{ cosec } \phi = 0.2 \text{ cosec } \phi$. $DC = BO - ED = 0.2 \text{ cosec } \phi - 0.2 \cot \phi = 0.2 (\text{cosec } \phi - \cot \phi)$. From a table of natural trigonometric functions, cosec 63 degrees 13 minutes 32 seconds $= 1.12009$, and the cotangent is 0.50458, as previously found; hence, $DC = (1.12009 - 0.50458)\ 0.2 = 0.61551 \times 0.2 = 0.1231$. Since $x = FD + DC$, $x = 2.38 + 0.1231 = 2.5031$ inches.

Another method of determining the angle ϕ is the following: Let $O'X$ and YF be the axes of rectangular coordinates; then the equation of the large circle is $x^2 + y^2 = r^2 = 1.2^2$. The coordinates of the point D are $x_1 = 2.38$ and $y_1 = -2.053$. Let m = tangent of angle $A'DF$ or IDF. Then, it is shown in analytical geometry that $(x_1^2 - r^2)\ m^2 - 2\ x_1\ y_1\ m + y_1^2 - r^2 = 0$. Substituting the values of x_1, y_1, and r, $(2.38^2 - 1.2^2)\ m^2 - 2 \times 2.38 \times -2.053\ m + (-2.053)^2 - 1.2^2 = 0$. Expanding, collecting, and combining terms, $4.2244m^2 + 9.77228m + 2.774809 = 0$. If it is desired to obtain the cotangent instead of the tangent, all that is necessary is to substitute $\frac{1}{m}$ for m (since the cotangent is the reciprocal of the tangent), and the last equation, after reduction becomes $2.774809m^2 + 9.77228m + 4.2244 = 0$. The roots of this equation are the same as those previously found, except that they are negative, the negative sign merely indicating that the tangent lines slope from D upward to the left instead of upward to the right.

PROBLEM IN MENSURATION

J. C.—A circular cylindrical tank, shown in Fig. 1, is 5 feet in diameter and 12 feet long, and rests at an angle of 30 degrees with the horizontal; if the tank contains 400 gallons of water, what is the distance x?

Answered by J. J. Clark, Scranton, Pa.

A.—Two conditions are imposed—the angle of rest and the volume of water—and both cannot be fulfilled at the same time, as a little consideration will show. According to the conditions, the tank would be represented by the outline $AEFD$, and the water level by the line KF, whereas the tank should be represented by the outline $ABCD$ and the water level by HC. In the latter case, the volume of the water is greater than one-half the volume of the tank, which is $\frac{1}{4}\pi \times 5^2 \times 12 \times 7.48052 = 1762.56$ gallons, one-half of which is 881.28 gallons, since one cubic foot contains 7.48052 gallons. It will be assumed, therefore, that it is desired to know the distance x when the tank contains 400 gallons, without regard to the angle of rest. The shape of the solid formed by the water is indicated by Fig. 2. If the water level coincides with the diameter AB of the bottom of the cylinder, the volume of the shape formed by the water is $V = \frac{2}{3}\pi r^2 h$, in which $r =$ radius $OA = OD$ and $h =$ height HD. In the present case, $r = 2.5$, $h = 12$, and $V = \frac{2}{3} \times 2.5^2 \times 12 = 50$ cubic feet $= 50 \times 7.48052 = 374.026$ gallons. Hence, the water level must be a little higher than AB in order that the tank may hold 400 gallons. The shape formed by the water is represented by the outline $EHDF$. The volume of a solid having this shape is expressed by the formula

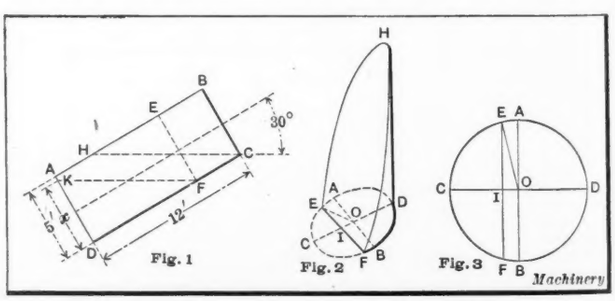
$$V = \frac{h}{3b}[a(3r^2 - a^2) + 3r^2(b - r)\phi] \qquad (1)$$

in which h and r have the same values as before, $b =$ distance DI, $a = EI$, and $\phi =$ angle EOD, in radians. This formula may be used also when DI is less than the radius OD. In the present case, a, b, and ϕ are not known, but by assigning a value to b, a and ϕ are readily found. Evidently, b is a little greater than the radius $r = 2.5$; assuming that it is $2.7 = DI$, Fig. 3, $CI = 5 - 2.7 = 2.3$. Since $EI = a$, $a^2 = 2.7 \times 2.3 = 6.21$, and $a = \sqrt{6.21} = 2.4920$. $OI = 2.7 - 2.5 = 0.2$, and $\cos EOC = \frac{0.2}{2.5} = 0.08$; whence, $EOC = 85$ degrees 24 minutes 41 seconds, and $\phi = 180$ degrees $-$ 85 degrees 24 minutes 41 seconds $= 94$ degrees 35 minutes 19 seconds $= 1.65088$ radian. In Formula (1), $V = 400$, when reduced to gallons, and the formula may be written

$$f(V) = \frac{h}{3b}[a(3r^2 - a^2) + 3r^2(b - r)\phi] \times 7.48052 - 400 = 0. \qquad (2)$$

Substituting the values of h, b, a, r, and ϕ, $f(V) = 14.929$. When $b = r = 2.5$, Formula (2) reduces to $f(V) = \frac{2}{3}r^2 h \times 7.48052 - 400 = -25.974$. Consequently, b lies somewhere between 2.5 and 2.7; assuming that it is 2.6, $CI = 5 - 2.6 = 2.4$; $a^2 = 2.6 \times 2.4 = 6.24$, and $a = \sqrt{6.24} = 2.498$. $OI = 2.6 - 2.5 = 0.1$; $\cos EOC = \frac{0.1}{2.5} = 0.04$; $EOC = 87$ degrees 42 minutes 27 seconds; and $\phi = 92$ degrees 17 minutes 33 seconds $= 1.61081$ radian. Substituting in Formula (2), $f(V) = -5.590$. Arranging these results in the form of a table, and using second differences, find by the method of interpolation that for $f(V) = 0$, $b = 2.6273$, which is the value of x, Fig. 1, when the tank contains 400 gallons. The angle KFD is then readily found, since $\tan KFD = 2.6273 \div 12 = 0.21894$, or $KFD = 12$ degrees 20 minutes 58 seconds. It is here assumed that the line EF represents the end of the cylinder.

b	$f(V)$		
2.7	14.929		
		−20519	
2.6	−5.590		135
		−20384	
2.5	−25.974		



Figs. 1 to 3. Diagram illustrating a Problem in Mensuration

OPERATING THE GRIDLEY MULTIPLE-SPINDLE SCREW MACHINE[1]

COMPLETE INSTRUCTIONS FOR TOOLING, SETTING UP, AND OPERATING

BY DOUGLAS T. HAMILTON[2]

INASMUCH as there are no cams to design in connection with the Gridley multiple-spindle automatic screw machine, and also as the time required for the longest single operation is the time necessary to make one piece, the first step in determining upon the tooling arrangement is to decide on the longest single operation. This, in some cases, cannot be done without some preliminary calculations; to arrive at a satisfactory result, it is necessary to decide on a suitable speed for the work and the correct feed for the tools. The feed, however, can be changed later by a gear-box mechanism, which is one of the important advantages of this type of machine.

A point that is of equal, if not greater, importance, especially when a large number of the same parts must be made, is to determine the best method of applying the tools to the work. The operations should be laid out so as to divide the cuts between the various tools, say on the turret-slide, so as to obtain the greatest possible production without crowding any one tool with a heavier feed than it will stand without frequent resharpening. It is also good practice, when the work is of irregular form, to cover the irregular part with a forming tool. In fact, this plan should be used with most work, whether it is plain or of irregular shape, especially when the part to be formed is not greater in length than two and one-half or three times its smallest diameter. When the forming tool is of the vertical type and covers several shoulders, provision need be made in the gage for testing only one diameter, as the forming tool automatically takes care of all the other parts covered by it.

It should also be borne in mind that on this type of multiple-spindle automatic screw machine, the threading spindle is operated independently of the turret, and consequently the cases are extremely rare when the threading operation will be the longest single operation. It is, therefore, obvious that the longest single operation will be done by a tool in either the forming slide or the turret. As all the tools on the turret are advanced toward the bars of work at the same feed, it is a comparatively simple matter, when the longest operation is to be performed from the turret, to select the tool or tools that will govern the time required to make one piece.

As an experienced operator can, with this type of machine, greatly increase production over that which can be accomplished by one not familiar with its principal features, it is evident that a careful study of the principal operating mechanisms and their functions is highly advantageous. This information can be obtained from the articles dealing with this subject that have previously appeared in MACHINERY. On some other types of automatic screw machines, it is absolutely necessary, in the majority of cases, for the operations to be laid out and cams made. With this machine, however, it is not necessary to make any cams, except in rare cases where special attachments are to be operated from the turret or forming slide. It is general practice, however, for a tool-setter to lay out the order of operations, outlining the type of tools to be used and specifying the longest single operation. If a tool-setter is not employed for this work, the operator must go ahead and set up the machine. In this case, setting up the machine is largely a cut-and-try method, but owing to certain features that this machine possesses, this method can be used with very satisfactory results.

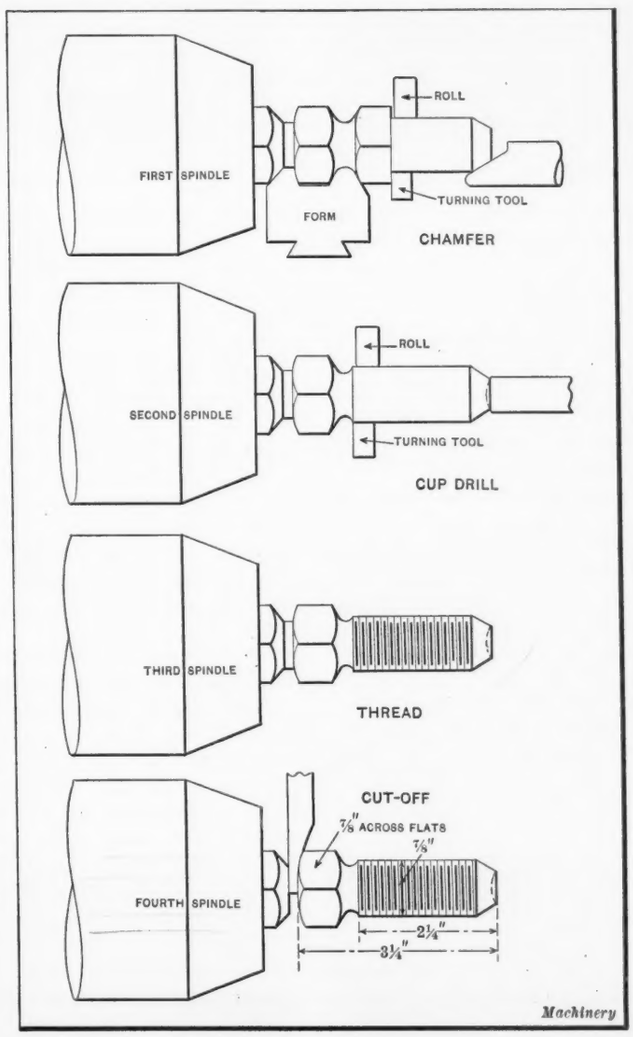


Fig. 1. Order of Operations in making Set-screw on Gridley 1¼-inch Multiple-spindle Automatic

Method of Tooling

The question of deciding what tools to use on the turret and on the forming and cutting-off slides is governed almost entirely by the character and shape of the work. If the piece to be made is a simple shoulder screw, there is no question but that the standard box-turner should be used to perform most of the work of breaking down the body and head of the screw with the forming tool. One stud-turner or box-turner, depending on the number of shoulders on the work, can be used for finishing in the second position. The threading is then done in the third position, and the piece cut off in the fourth position. As has been mentioned in a previous article, it is necessary to use a special cam on the turret drum when an end-working tool is used in the fourth position.

Preparing Machine for New Set-up

If the machine has already been set up and in operation on a certain part and it is necessary to change it over to produce another piece, the method of procedure will be somewhat as follows: If the part to be produced is not at all similar to that previously made, it is necessary to remove the spring chucks and feed-chucks, so as to insert new pads in them to accommodate the size and shape of bar to be handled. As was mentioned in the June, 1917, number of MACHINERY, the feed-chucks can be removed by withdrawing the plug from the star back-stop and rotating the latter a fraction of a turn, when the pusher-tubes can be withdrawn. The screws are then removed from the feed-chucks and pads of the proper size and shape inserted.

The next step is to remove the chucks. This is done by first taking off the nose caps with a spanner wrench, the pressure on the chucks being first relieved by the hand-lever to release the fingers from the chuck-closing spools. The spring chucks can then be removed and pads of the correct size and shape

[1]For other articles on the Gridley multiple-spindle automatic screw machine practice, see "Screw Machine Tool Equipment," October and December, 1917 and January, 1918.

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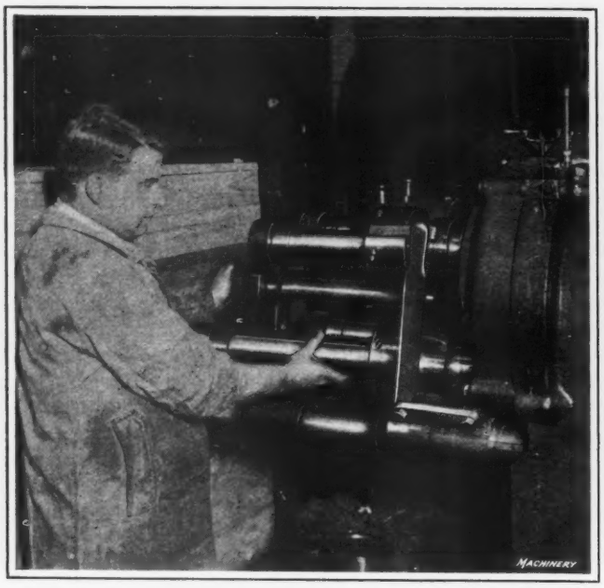

Fig. 2. Removing Feed-chuck Sleeves from Work-spindles

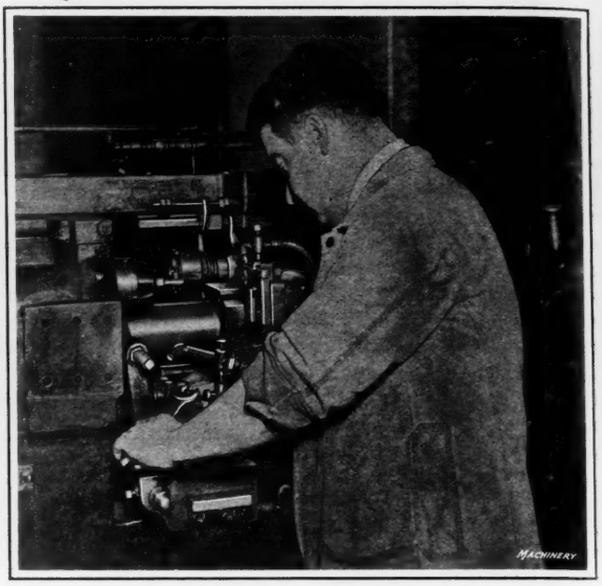

Fig. 3. Setting Forming Tool-holder

inserted. Following this, all the tools are removed from the turret and cross-slide, providing that none of them are adapted to the work to be produced.

Turret, Forming Cams, etc.

Three sets of feed-cams for operating the tool-slide, as shown in Table 1, which appeared in the July, 1917, number of MACHINERY, are provided for each size of machine. These cams cover the same section of circumference of the cam-drum, but advance the tool-slide different amounts, depending upon the rise of the cam. The feed for the tools is controlled, in connection with the cams, by a change-gear box, as shown in Fig. 5.

It is not always necessary to use a cam of exactly the right rise. For example, suppose it is necessary to turn a screw, the length of which is 1 1/2 inch, on the 3/4-inch machine. With either the 3-inch or the 4 9/16-inch cam, the desired feed may be obtained by changing the levers in the change-gear box. With the 3-inch cam, the drum will be made to rotate faster than with the 4 9/16-inch cam, and in this way the same rate of feed will be obtained. Of course, it is impossible to turn a greater distance than the rise on the cam, so that a cam should always be selected which will give a greater rise than that actually required to turn the work to the desired point.

Example of Set-up of Machine

As a practical example to show how the machine is set up, the method to follow in making the screw shown in Fig. 1 is given. This set-screw is made from square stock that measures 7/8 inch across the flats, or 1.237 inch across the corners. It will be necessary, therefore, to make this piece on a 1¼-inch machine. As shown, the operations consist of forming, turning, and chamfering; turning and cupping; threading; and cutting off.

The first step, after deciding on the order in which the operations are to be handled, is to select the proper spindle speed for the work and put on the necessary change-gears. Assuming a surface speed of 85 feet per minute, it will be seen from Table 3 in the July, 1917, number that a spindle speed of approximately 276 revolutions per minute is required. To secure this speed, it is necessary to use a 36-tooth pulley gear and a 52-tooth driving gear. The way in which these gears are put on the machine is illustrated in Fig. 17, in the June, 1917, number, where a description of the operation also appears.

The next step is to select spring chucks and feed-chucks of the proper size and shape, and insert these in the spindles. To insert the feed-chucks, it is necessary to remove the feed-tubes. This is done by removing the locking plug from the star-stop, as shown in Fig. 2, and rotating the stop a fraction of a turn, so that the feed-tube can be withdrawn. The feed-chucks are then removed and replaced by those of the proper size and shape, after which the tubes are again inserted and the star-stop brought back into its former position and locked. The spring collets are now removed by taking off the nose caps with a spanner wrench, and collets of the proper size and shape are inserted. Bars of stock can now be placed in all

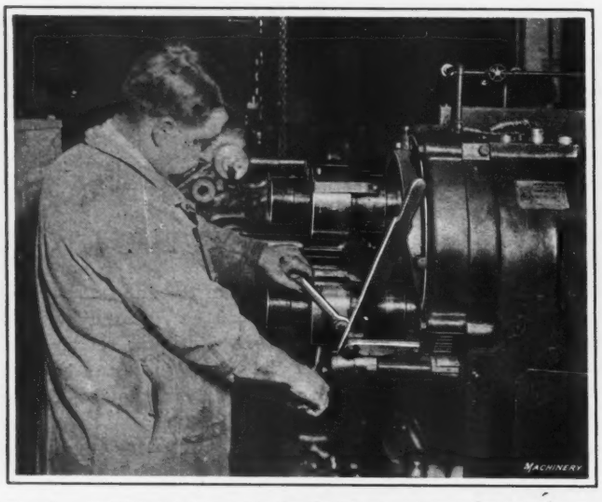

Fig. 4. Adjusting Tension of Spring Chucks to Bars so that they will be held securely

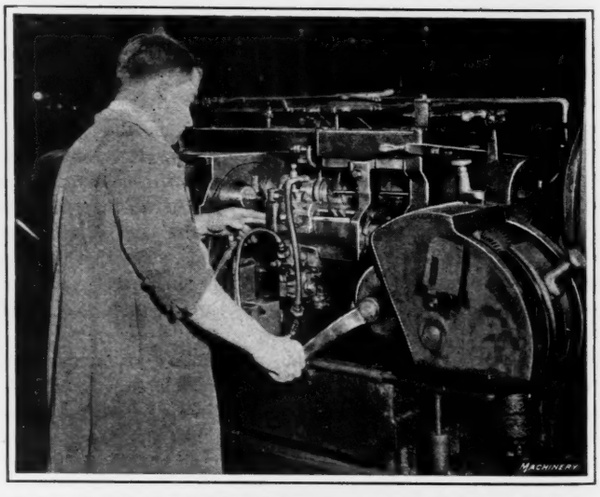

Fig. 5. Setting Box-turner—Cranking Machine by Hand to bring Roll to High Point of Tool-slide Cam

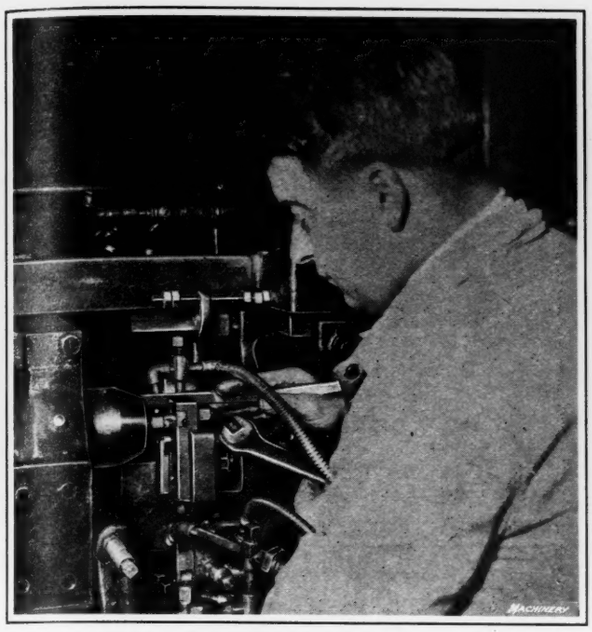

Fig. 6. Setting Box-turner Relative to Face of Chuck

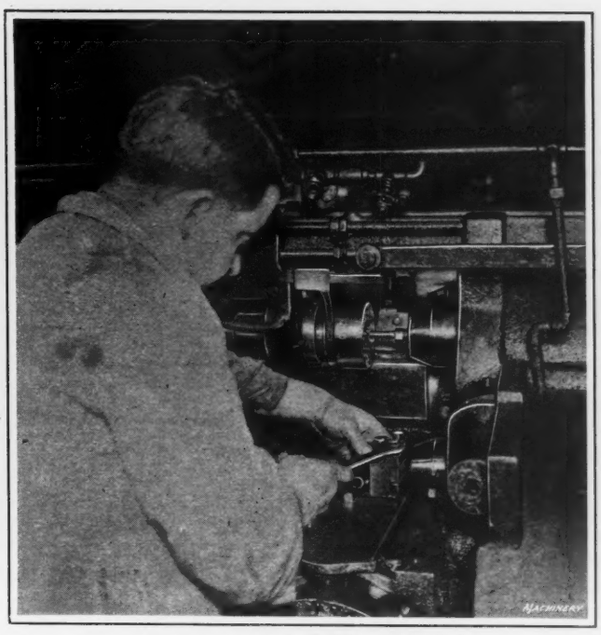

Fig. 7. Setting Cutting-off Tool

four spindles, but should not be inserted before the ends have been chamfered to remove any burrs.

Setting Forming Tool Relative to Chuck

We now select a forming tool of the desired type; this, as shown in Fig. 1, is a dovetail or vertical type of tool, which must be made special for the job. This is clamped in a suitable holder; the latter is fastened to the forming slide, as shown in Fig. 3, and then the tool is set in the correct position relative to the chuck. With the bar protruding through the chuck, the tool can be easily set to the correct height and diameter by means of a scale. The distance that it is located from the face of the chuck is governed by the shape of the work. The forming tool should always clear the face of the chuck by not less than 1/32 inch, while 1/16 inch is preferable.

Adjusting Tension of Spring Chuck

The spring chucks should be adjusted to the bars of stock so as to hold them securely against the thrusts of the cutting tools. As explained in a previous article, the spring chucks used on this type of machine are closed on the work by being forced into a nose cap, held on the front end of the spindle. In order to make this adjustment, it is necessary, as shown in Fig. 4, to index the spindle carrier and bring each successive spindle into the first stock-feeding position to make the adjustment. The collar carrying the chuck-closing fingers is held on the sleeve by means of a set-screw, which should be released and the collar adjusted, so that when the hand chuck-closing lever is operated, the grip of the chuck on the work can be tested. The collar should be so adjusted that when the chuck is forced down on the work, the chuck will prevent the work from being moved by the thrust of the cutting tools.

Setting Box-turner

After all the spring chucks have been properly adjusted, the next step is to set the box-turner. The tool-slide is advanced by cranking the machine by hand, as illustrated in Fig. 5, until the roll is on the high point of the tool-slide cam and the slide advanced to its extreme position. The box-turner is then placed on the slide and, by means of a scale, the distance from the front edge of the cutting tool to the face of the chuck is measured. This measurement is only approximate, as it may later be necessary to make a slight adjustment. The first tool is required to turn a distance of 1⅝ inch only. As shown in Fig. 6, the box-turner is adjusted along the tool-slide and, when properly located, is clamped by the T-bolt, as illustrated.

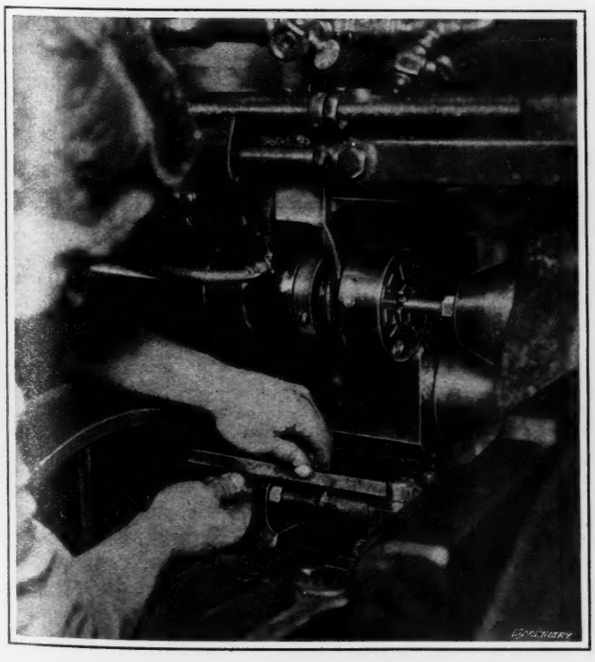

Fig. 8. Setting Swinging Stop

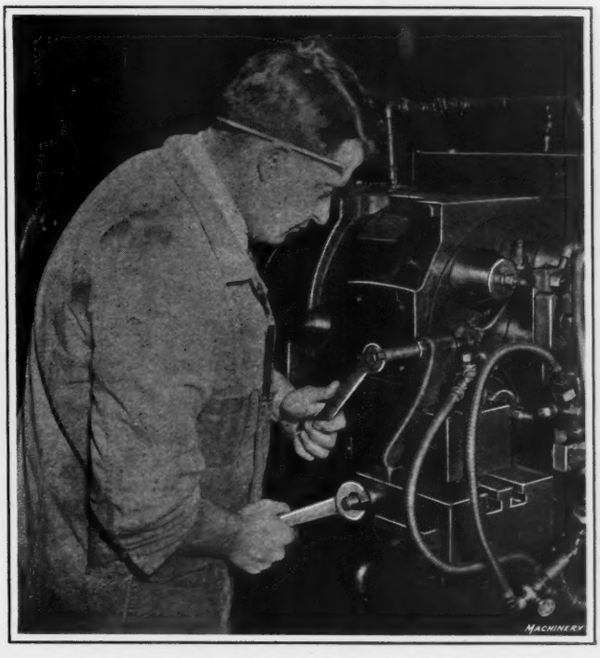

Fig. 9. Setting Forming Tool to turn to Correct Diameter

The turning tool can now be set to turn the bar to the approximate diameter. To do this, the supports are withdrawn from contact with the work and the tool-slide returned by operating the hand crank. Then the bar stock in the first-position spindle should be fed forward by hand until it projects far enough from the face of the chuck to allow the bar to be reduced for a length of about 1/2 inch. The chuck is now closed by hand and the belt shifter pulled over to start the spindles rotating. The box-turner is now advanced toward the work, by cranking the machine by hand, and the tool set to the work. When the proper diameter has been obtained, the supports are brought up into contact with the work and locked in position. The same procedure is followed in setting the box-turners in the second position, the spindle head being inclined to bring the partly turned bar into this position.

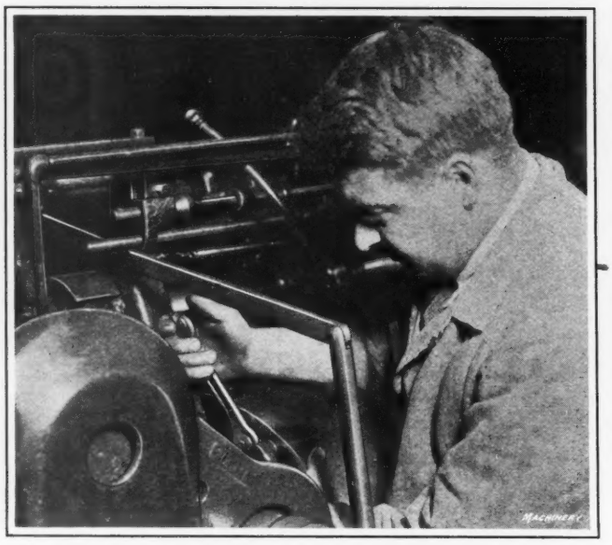

Fig. 10. Setting Tripping Dogs to change from Fast to Slow Feed

Setting Cutting-off Tool

In order to set the cutting-off tool, the stock should be pulled back from the face of the chuck in the fourth position, so that the tool can be set to the proper height and to its extreme forward position. The machine is cranked by hand until the roll operating the cutting-off slide is on the high point of the cam. The cutting-off tool is then set at the proper distance from the face of the chuck, to the proper height, and also slightly in advance of the center of the chuck, so that it will be certain to cut the stock completely off.

Setting Stop

As it is not necessary in this case to use any tool working from the tool-slide in the fourth position, the swinging stop that works in the fourth position can be used; it is set as shown in Fig. 8. The chuck is opened and the bar fed out to the total length required, taking into consideration sufficient stock for the part to be made, the amount used by the cutting-off tool, and that necessary for the cutting-off or forming tool to clear the chuck. The required amount is measured by a scale, as shown, the chuck tightened, and the stop set to the proper position.

Setting Forming Tool

The forming tool can now be set. The machine is cranked by hand to bring the stock that is in the fourth position around to the first position. Prior to this, however, the cutting tool should be set for height relative to the center of the chuck. The machine is again cranked by hand until the roll operating the forming slide is on the high point of the forming cam. By means of the adjusting screw, as shown in Fig. 9, the forming tool is fed in until it has reduced the work to the proper diameter; the spindles, of course, are running when the tool is being fed in. When the work has been reduced to the proper diameter, the stop for the forming slide, as shown in Fig. 9, is adjusted. This should be so adjusted that it will create a slight tension in the lever operating the forming slide, thus reducing the feed slightly at the end of this cut and assisting in retaining the correct diameter of the work. After the stop has been adjusted, the locking nuts should be tightened sufficiently to insure that there will be no motion.

Setting Tripping Dogs

The setting of the pointing or cupping tool is a comparatively simple matter. The next step is to set the tripping dogs, Fig. 10, for operating the machine on the slow and fast feed and indexing the spindle cams. The dogs, as has been mentioned in a previous article, are carried on the side of the main cam-drum and operate a Johnson friction clutch, which changes from the slow to the fast feed. The spindle cams are indexed by a Geneva stop mechanism, which has also been previously described. The main point to observe in setting the tripping dogs is to have the tool-slide, forming slide, and cutting-off slide operating on the fast feed as long as possible to save time on the job. For instance, in setting the tripping dog for changing from fast to slow feed for the box-turner, the tool-slide should be operated on the fast feed until the tool has almost reached the work, before it is thrown into the slow or cutting feed. Of course, it is necessary to set the dogs so that the tools will not dig into the work.

Before setting the threading die, it is advisable to have the machine work under power to see that all the tools are functioning properly, and at this time it is also possible to change the change-gear levers until the tools have been given all the feed that they will conveniently stand. In starting up on any job, it is advisable to start with the slowest possible feed and increase this feed after all the tools have been set. In this way there is less likelihood of breaking any of the tools, and the feed that is best suited to all the tools can be selected.

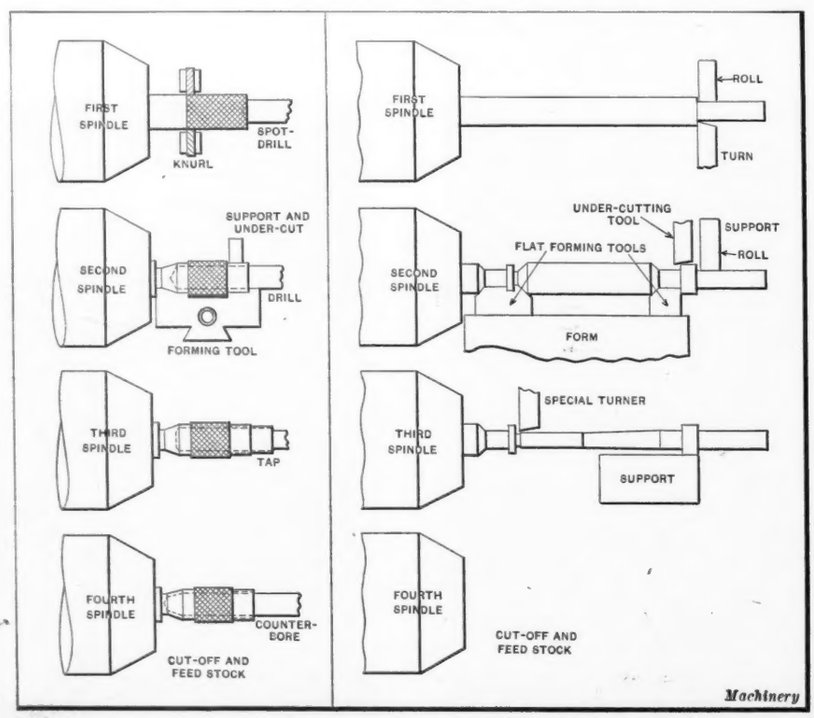

Fig. 11. Set-up for producing Knurled Sleeve on 3/4-inch Machine

Fig. 12. Method of tooling for producing Long Slender Part

Setting Threading Mechanism

The setting of the threading mechanism was clearly described in the July number of MACHINERY. It should be borne in mind that in cutting threads on the Gridley multiple-spindle automatics, the working speed of the die-holder is the differ-

ence between its own speed and that of the work-spindles. This gives the number of effective or cutting turns made by the die or tap. In cutting right-hand threads, the die-holder always runs slower than the work-spindles. In cutting left-hand threads, the die-holder always runs faster than the work-spindles.

When the screw has been formed and turned to the desired size, the work is indexed to the third position and the die set. The die can start immediately after the work has been indexed to the third position; or if sufficient time is available to thread, the high point of the cam should be set to coincide with the time that the turning tool starts to work. The tension on the spring is then adjusted to start the die. Before the die lever starts to work, the clutch should be in slow speed, and the tripping lever in position for right-hand threading. Then the machine is started and the die allowed to run onto the work to the required length. The machine is stopped and the adjusting screws set so as to trip the lever into fast speed to run off the die. As this finishes the setting of the machine, the high-speed dog is set on the high point of the cam. The machine is indexed around and the slow-speed dog set at the point where the turning operation commences. The machine should never be cranked by hand by the high-speed dog, and the operating lever should always be removed before starting the machine into operation.

Method of Tooling for Knurled Sleeve

In order to assist the operafor of the Gridley automatic in deciding on the method of tooling this machine for producing various parts, several examples are given, and the method of tooling for each part is described. The first example is a knurled sleeve, which is shown in Fig. 11. This piece is to be made from a bar of cold-rolled steel 5/8 inch in diameter and is 1 11/16 inch long. It can, therefore, be handled on the 3/4-inch machine. The operations consist in knurling, drilling, turning, forming, tapping, counterboring, and cutting off. The method suggested for handling the part is: drilling and knurling in the first position; turning, drilling, and forming in the second position; tapping in the third position; and counterboring, cutting off, and feeding stock in the fourth position.

As was mentioned in the July, 1917, number, and illustrated in Fig. 31, a special lead cam is necessary when operating a tool-slide tool in the fourth position. It is also necessary to employ a special stop, as shown in Figs. 11 and 12 of the June number. The counterbore must pass through a hole in this stop, and it must be elongated so that the cut-off slide can be advanced while the counterbore is working. With the exception of this one modification, the tooling can be handled in regular order. The tools used are as follows: standard knurl-holder operating from the tool-slide; spotting drill; vertical forming tool; drill and holder; support and a special under-cutting tool; tap; counterbore and floating holder; cut-off tool; special stop; and stripper to remove work from counterbore when tool-slide is returned.

Tooling for Slender Piece

The tooling for the piece shown in Fig. 12 is more difficult. This is made from a round bar of 9/16-inch cold-rolled steel, is 5⅜ inches long, and is handled on the 3/4-inch machine. As shown, the operation performed in the first position is turning with a regular box-turner for a distance of 1⅜ inch, reducing the bar to 3/8 inch. In the second position, the part is formed by two special flat forming tools, and the shoulder is reduced by an under-cutting tool. The forming tool-holder is of the double-deck type and carries two flat forming tools. In the third position, the center portion of the part is reduced to the desired diameter and shape by a special taper-turning tool, the work being supported by a special support. The method of operating a taper-turning tool on the Gridley automatic was previously illustrated and described in the September, 1917, number of MACHINERY. This particular part requires a special guide to conform to the shape of the work. The piece is cut off and the stock fed out to the swinging stop in the fourth position. For this particular part, the longest single operation is evidently turning the taper portion.

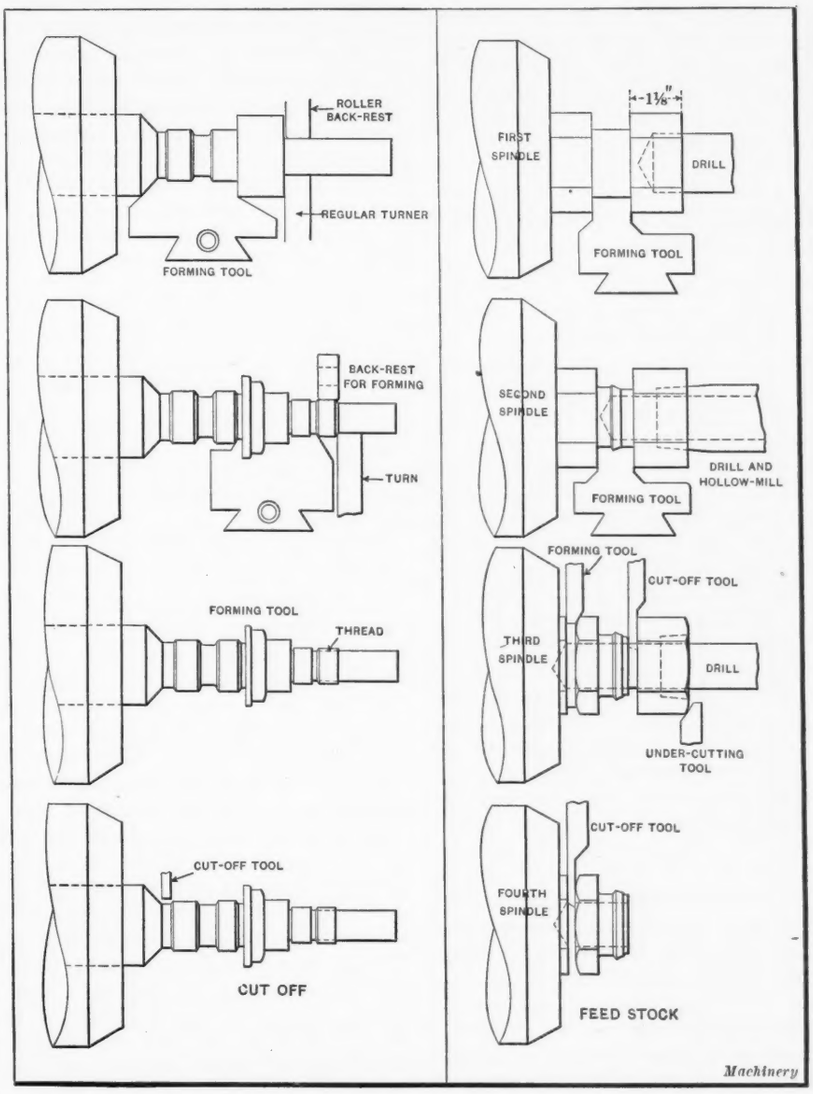

Fig. 13. Example of Work completed largely by Forming Tools

Fig. 14. Method of tooling so as to produce Two Nuts at One Time

Tooling for Part Completed by Forming

A part in which the longest single operation is performed from the forming slide is shown in Fig. 13. In order to reduce the amount of work to be handled with the forming tool, the double-deck type of holder is used, and the part is formed in the first and second positions. In the first position, the part is turned with the regular box-turner and formed with a vertical forming tool, the turner supporting the work against the thrust of the cut of the forming tool. In the second position, the part is finish-turned with an under-cutting tool carrying a support, and is finish-formed with a vertical forming tool. In the third position it is threaded; and in the fourth position it is cut off and the stock fed out to the stop. This part is made from a bar of 1¾-inch cold-rolled steel, and is therefore handled on the 1¾-inch machine.

Tooling for Producing Two Pieces at One Time

Fig. 14 shows a method that can be employed on comparatively plain parts that are short and do not require threading. These check nuts are made from a bar of hexagonal stock cold-rolled steel, 1⅞ inch across flats, and are handled on a 2¼-inch machine. They are threaded in a second operation. Reference to Fig. 14 will show that the operations performed in the first position are drilling the first nut and rough-forming the second. A double-deck forming tool-holder is used, and in the second position, the center part of the bar is finish-formed, the first nut finish-drilled, the second nut partly drilled, and the first nut counterbored with a special form of hollow-mill. It will be noticed that the hollow-mill carries a drill.

In the third position, the second nut is finish-drilled, the first nut chamfered with an under-cutting tool, the tool-slide being returned before the first nut is cut off, and the second nut chamfered with a forming tool. A double-deck type of cutting-off tool is used on the cutting-off slide, so that in the fourth position, the second nut can be cut off. The stock is fed out to the stop in the fourth position, and the sequence of operations repeated on two more parts.

* * *

THE GISHOLT METHOD OF TRAINING INSTRUCTORS

For six years past the Gisholt Machine Co., Madison, Wis., have been developing a method for training expert operators on the Gisholt machine, which has gradually become a complete system for giving mechanics a general training in a very brief period of time, making them not only far more efficient in their own work, but also able to instruct others in the operation and care of both the machines made by the Gisholt Machine Co. and machine tools in general. The methods employed have been the result of a gradual evolution during a long period of years, and the Gisholt Machine Co. have considered these methods one of their assets in business, as they have been enabled by this means to train operators and instructors of operators more rapidly than could any of their competitors. However, the present war exigencies, which emphasize more than anything else could have done the lack of instructors for training men and women, have made it a patriotic duty of the Gisholt Machine Co. to give to other machine tool builders and to other lines of industry the principles involved in their scheme of intensified training, and this duty the company has voluntarily and freely assumed. In order to bring the information before other manufacturers at as early a date as possible, the details of the Gisholt instruction system were published in the *American Machinist* of April 18 and 25. MACHINERY is glad of the opportunity to direct attention to this matter so as to give the widest possible publicity in the mechanical field to this intensified course of instruction for mechanics. In these unprecedented times, everyone should contribute for the general good every idea, method, and principle that will aid in accomplishing the one purpose to which the nation is committed.

It is believed that manufacturers will find in the Gisholt method something upon which they can build in order to establish training departments for the intensified training of men to become instructors who can intelligently and ably convey knowledge to others. The intensified training given in the Gisholt plant to men sent to them by other firms is equivalent to the intensified training in the officers' training camps, where young men become officers in a fraction of the time usually required by a course arranged under peace-time conditions. By working intelligently and industriously, a mechanic acquires in a month of intensified training the amount of knowledge and understanding of the underlying principles of machine construction and operation that it would, even with proper ordinary instructional facilities, take him a long period of time to obtain. The Gisholt Machine Co. are to be commended upon their patriotic spirit in being willing to share with other machine manufacturers and allied lines of industries the advantages that would otherwise have accrued for years to come to them alone by the development of this system of intensified training.

EXAMINATIONS IN MACHINE SHOP PRACTICE

BY B. A. LENFEST [1]

The writer has tried, with considerable success, the plan of giving students in machine shop practice the test questions some time before the written test is to take place. By this plan all the students can treat the problems in the same manner as a shop superintendent or engineer, for all the books and notes are available and are intended to be used freely. The test period, which is forty-five minutes long, is then used largely in putting the notes and calculations in good shape on standard size paper and not for making extended computations. The only restriction is that there must be no exchange of work or communication between students. Although this plan has been tried, to a limited degree, in some colleges, the writer believes it is the first time it has been tried in a secondary school. It is realized that groups of students will probably do the work together and that some may copy the results obtained by the more industrious, but even the copying requires some work, and the records of the term's work show what students are reliable and resourceful.

The examination given last January consisted of the following questions; the value of each question is also stated:

1. Hand in notebook containing the complete mechanism of the 12-inch Reed engine lathe with calculations for all speeds (with armature running at 390 revolutions per minute), all feeds, and the thread-cutting devices. 40 per cent.

2. If an engine lathe has a lead-screw with ten threads per inch, calculate all combinations of change-gears needed to cut threads of 3-, 2½-, 2-, 1½-, 1¼-, 1-, and ¼-millimeter pitch; how many change-gears are necessary in the set? 15 per cent.

3. If an engine lathe has a nine threads per inch lead-screw, what change-gears are necessary to cut the U. S. standard threads from ¼ to 1 inch, inclusive? 15 per cent.

4. What time is needed to turn and face 100 disks, 12 inches in diameter and 4 inches thick, with one roughing and one finishing cut? The roughing cut is to be at 40 feet per minute and the finishing cut at 60 feet per minute maximum. 30 per cent.

In this test, a complete notebook must be prepared beforehand, used in the test, and then handed in for examination. The second question requires a table for metric threads for an engine lathe fitted with an English pitch lead-screw; the war and our relations to our allies brings this question to the front and warrants its discussion and solution. As the U. S. standard thread had not been studied at the date of the test, the third question was designed to require research, at least enough to find an explanation of what diameter and pitches were to be provided for, if the lathe was fitted with change-gears to cut threads of the limits stated. The fourth was a simple production problem, but impossible of solution without a finished notebook and preliminary calculation. The results that the test brought were very gratifying. About 95 per cent of the students passed the examination, the chief trouble being arranging a neat, concise, handy notebook. It was especially noticeable that the last question, though much harder than the two preceding, had as high a percentage of correct results, and subsequent discussion revealed a surprising interest in questions of production, shop management, overhead costs, advertising, and the sales force, with an intelligent appreciation of matters seldom considered in trade and secondary schools.

* * *

Wall St. measures values in dollars and believes in the magic power of money to produce anything desired. But the stress of war has brought a realizing sense to business men generally that money in itself is powerless to make even a pin. Men and materials are the essentials; with them all things are possible, but without them all the gold is worthless. Many of the early attempts to make guns and shells failed because bankers had little conception of industrial methods, requirements, and limitations. They found that the rarest commodity is brains capable of organizing mechanics, developing equipment, and planning production in large quantities, quickly and efficiently.

[1] Address: 1524 Seventy-sixth St., Brooklyn, N. Y.

HEAT-TREATMENT OF GEAR BLANKS[1]

During the past few years great advancement has been made in the heat-treating and hardening of gears. In this advancement the chemical and metallurgical laboratory have played no small part. However, the condition of the blanks given to the machine shop to be machined has not received its share of attention in the heat-treating department of many forge shops, and in many cases has been neglected or not considered by the machine shops themselves. This is especially true of shops using only the lower carbon steels.

There are two distinct types of gears, one of which may be termed "carburized" and the other "heat-treated." The difference in the composition of the steel used for the two types is entirely in the carbon content, the carbon never being higher than 0.25 per cent in the carburizing type, while in the heat-treated gears it is seldom lower than 0.35 per cent. The difference in the completed gear is in the hardness. The carburized gear is file hard on the surface, with a soft, tough, and ductile core, which withstands shocks, while the heat-treated gear has a surface that can be touched with a file, but has a core of the same hardness as the outer surface.

With the exception of some of the higher grades of alloy steels, where the percentages of special elements, such as nickel and chromium, run quite high, which causes a slight air-hardening action, the carburizing steels are soft enough for machining when air-cooled from any temperature, including the temperature at which gear blanks are finished at the hammer. This condition has led many drop-forging and manufacturing concerns to believe that the annealing of the blanks involves an unnecessary expense, and often the blanks are only heated to a low temperature, many times just until color begins to show, to relieve the so-called "hammer-strains." While this is only a compromise, it is better than no reheating at all, although it does not properly refine the grain of the blank to insure good machining conditions.

"Annealing" may be defined as the heating of steel to a temperature slightly above the highest critical point, and cooling it slowly either in the air or in the furnace. The object of annealing is twofold—to relieve mechanical strains, and to soften and produce refinement of the grain. Theoretically, annealing should be accomplished at a temperature very slightly above the critical point. In practice, however, the temperature is raised to a somewhat higher point, but temperatures exceeding the critical point by 100 degrees F. should never be used.

Annealing 0.15 to 0.25 Per Cent Carbon Steels

For annealing low-carbon steels having a carbon content of about 0.15 to 0.25 per cent carbon, the following temperatures have been found to produce uniform machining conditions:

0.15 to 0.25 straight carbon steel.—Heat to 1650 degrees F.; hold at this temperature until the work is uniformly heated; then remove from the furnace and cool in the air.

0.15 to 0.25 per cent carbon, 1½ per cent nickel, ½ per cent chromium steel.—Heat to 1600 degrees F.; hold at this temperature until the work is uniformly heated; then remove from the furnace and cool in the air.

0.15 to 0.25 per cent carbon, 3½ per cent nickel steel.—Heat to 1575 degrees F.; hold at this temperature until the work is uniformly heated; remove from the furnace and cool in the air.

In the annealing of higher grades of chrome-nickel steel, with a nickel content of about 3 per cent and a chromium content of about 1 per cent, the operation is more difficult, as rapid cooling through the upper critical range produces a hardness due to the slight air-hardening properties of steel of this composition. To produce the best machining qualities in this steel, the following practice gives satisfactory results:

Heat to a temperature about 100 degrees F. in excess of the critical point, holding at this temperature for a considerable time to allow for thorough heating; cool rapidly, either by removing from the furnace into air, or opening up the furnace doors, to a point at which the forgings show no color in daylight; reheat to a point just in excess of the highest critical point and cool slowly in the furnace. The temperatures, length of heating, time and rate of cooling are dependent on analysis, size of forging, and weight of the load of forgings in the furnace.

Proper annealing makes it possible to machine the forgings easily, and subsequent troubles in the hardening plant are also greatly reduced. The advantages in hardening begin to appear in the carburizing operation, because steel of uniform grain will carburize more uniformly; a more even hardness is produced, and there are less chances for soft spots. The bores in the gears will also close in more uniformly, thus eliminating the condition where some gears require excessive grinding, while others have just enough stock to "clean up." All strains are also removed from the forging, eliminating to a great extent the distortion in hardening and the noisy gears that result from this cause.

Annealing of Gear Blanks Having a Carbon Content Higher than 0.35 Per Cent

The steels used for heat-treated gears have so high a carbon content that annealing after forging is necessary in order to make it possible to machine them, as it would be impossible to obtain satisfactory production from unannealed forgings, especially when made from alloy steels. As there are so many different compositions of steel for heat-treated gears, it is impossible to give specific directions, but the general procedure is practically the same as that used for the casehardening steel mentioned in a preceding paragraph that has 3 per cent nickel and 1 per cent chromium. More time must be given for the heating, and the rate of cooling must be closely watched, as well as the temperature at which the forgings are removed from the furnace. For a furnace load weighing 550 pounds, of medium section forgings made from 0.50 per cent carbon, 0.60 per cent manganese, 3 per cent nickel, and 1 per cent chromium, the following treatment gives very good machining conditions, both for the turning and gear-cutting operations:

Heat to 1330 degrees F., reaching this temperature in 2 hours. Hold at this temperature for 1½ hour, and allow the steel to cool in the furnace to 1170 degrees F., 1 hour being taken for the cooling. Reheat to 1230 degrees F., consuming ¾ hour for reheating. Hold at this temperature for 1¼ hour. Cool slowly in the furnace until a temperature of 900 degrees F. is reached, the rate of cooling not being faster than 75 degrees during the first hour. After 900 degrees has been reached, cool in the air.

If steels of this quality are not properly annealed, there will be hard spots in them, which, in forming the tooth, will cause the cutter to ride over the hard metal, thus producing high spots on the face of the tooth.

Hardness Test

The simple carburizing steels do not need to be tested for hardness after annealing, but alloy steels containing high percentages of nickel or chromium, and all heat-treated steels, require a hardness test. The Brinell hardness test has been found the most accurate for this purpose, but it should never be used without the aid of a microscope. By careful control of the annealing operation and with the aid of the hardness test, it is possible continually to produce forgings that will have uniform machining qualities and that will be soft enough to make possible a satisfactory rate of production. The following hardness numerals used in the manufacture of gears have been found to insure good machining qualities: 0.20 per cent carbon steel containing 3 per cent nickel and 1.4 per cent chromium—Brinell hardness numeral, 156-170; 0.50 per cent carbon steel containing 3 per cent nickel and 1 per cent chromium—Brinell hardness numeral, 179-187; 1.50 per cent chrome-vanadium steel—Brinell hardness numeral, 170-179.

* * *

The country's foreign trade amounted to over $9,000,000,000 in 1917, the exports reaching a total of $6,226,000,000, while the imports amounted to $2,952,000,000; this is a gain of nearly $1,300,000,000 over 1916. The excess of exports over imports has nearly doubled in the last two years, amounting to $3,274,000,000 in 1917, against $1,776,000,000 in 1915.

[1] Paper read by C. R. Poole, of the Frost Gear & Forge Co., Jackson, Mich., at the American Gear Manufacturers' Association convention, at White Sulphur Springs, W. Va., April 18 to 20, 1918.

STANDARDIZATION OF GEARING[1]

The subject of standardization as it pertains to industrial activities is receiving the attention of all the national organizations representing the various industries at the present time. The American Gear Manufacturers' Association has, therefore, considered it advisable for the advancement of the gear industry to appoint as one of its standing committees a "general standardization committee," together with a number of subcommittees, to consider and develop, from the mass of data now available in various forms, standards for use in this industry.

While the types of gearing differ from one another in many respects, there are a number of functions common to many or all of them, and an endeavor will be made in the following to outline some of the details that might be made standard for each type of gearing. Another matter of interest in this connection is that of symbols used to denote different dimensions in gearing calculations. Different text-books and handbooks use different symbols to represent the same dimensions, which makes it difficult to compare the results of different formulas. To overcome this difficulty, it might be well to have a nomenclature committee which would authorize a standard set of symbols for use in gear calculations. Working limits should also be adopted to assure standards of quality, these limits pertaining to such matters as the permissible running out in the blank and in the cutting of the teeth, the size of the hole, the width of the keyway, etc. Standard formulas for calculating the strength of all classes of gearing, with values to cover the various factors used, should also be adopted.

Bevel Gears

Within the last few years, bevel gears have been highly developed, due principally to the great advance in machinery for producing them. New formulas for calculating the dimensions of bevel gears, which differ from the usual or standard practice, have also been developed, the reference here being to the long addendum and the spiral type of gears. These formulas should be standardized, as the growing use for long addendum and spiral type gears makes it necessary that these be considered standard and not special types. Many bevel gears will continue to be cut with rotary cutters, and some consideration should be given to the proper cutters used in producing them.

Spur Gears

The spur gear is, by far, the most commonly used of all gears, and has theoretically and practically received the most consideration, both as regards design and production. Most of the theory of gearing can be studied from it, and the methods of producing it have been highly developed. For this reason, any standard adopted must be one that does not conflict with any method of production, but should be applicable to each and all of these methods.

Worm-gears

Within the last few years, worm-gears have become widely used. They are now employed for transmitting greater power at higher speeds than was thought possible in the past; but even now, with this great development, their design is not based upon complete analysis. There are so many conditions that enter into the design of worm-gears that it is almost impossible to design a drive with any certainty of success, unless the design is based upon a similar successful design. It would be well if the subcommittee on worm-gears of the American Gear Manufacturers' Association could investigate the many successful drives now in existence, and from these deduce some tangible working basis of design. There is a great lack of uniformity in calculating the dimensions of both the worm and the wheel, and also in the method of producing the worm, as well as in the selection of the material from which worms and wheels are made. It would be possible to develop standard formulas for worm and worm-wheel dimensions that would permit makers to produce similar gears for regular conditions.

[1]Abstract of a paper read by B. F. Waterman, of the Brown & Sharpe Mfg. Co., Providence, R. I., before the American Gear Manufacturers' Association convention, at White Sulphur Springs, W. Va., April 18 to 20, 1918. Mr. Waterman is chairman of the Standardization Committee of the association.

At the present time, multiple-threaded worms, for example, are not produced to a uniform standard. They may be either cut in a worm-thread milling machine with a straight-sided cutter, or on a lathe with either a straight-sided tool having the standard dimensions on an axial plane or a straight-sided tool having the standard dimensions in a plane normal to the helix of the thread. If these three methods are pursued, the thread of each worm would be different from the others, and a hob could be right for only one of them, the hob being made to the same system. Again, when the angle of thread with the axis becomes less than 72 degrees, it is the practice in some shops to make the hob with spiral flutes, as it works better than a straight-grooved hob of this angle, and in that case, the tooth proportions are calculated from the normal pitch. This indicates the necessity for standardization. The present length of the worm and the width of the face of the wheel might also need investigation and standardization.

Herringbone Gears

Herringbone gears have only been recently developed. The industry is highly specialized, and the only suggestion the author can make is that experience has taught him that they must be extremely well made if they are to do their work properly, and it would be desirable to determine definitely the degree of accuracy that should be demanded.

Sprockets

Chain sprockets present another highly specialized branch of gearing, and any work that the gear manufacturers would do with regard to standardization must have the sanction of the chain manufacturers. The latter hesitate to furnish chain to run on sprockets that they have not themselves cut, owing to the lack of standardization, and also to lack of knowledge on the part of many who attempt to cut sprockets as to the proper method in which they should be cut. Cooperation between the chain manufacturers and the American Gear Manufacturers' Association should be valuable in defining standard designs and methods of cutting sprockets.

Composition Gears

For several years past, gears of other materials than metal have been made to an ever-increasing extent. Until recently, these gears were usually made of rawhide or fiber, but today the two largest electrical companies in the country have developed a fabric composition that is used to probably a greater extent than any of the older materials. The working standards for any of these materials are different from those used for metal, and a different set of standard rules will be required.

Hardening and Heat-treatment

The best and most durable gears are those that are properly heat-treated or hardened, and standard methods for handling various kinds of steels used for gears should be developed. Such methods would be of inestimable value to every gear manufacturer and user. The steel manufacturers would, no doubt, willingly cooperate with the gear manufacturers in the determination of standard heat-treatment methods.

Inspection

Standard inspection methods for different kinds of gears are also required. This standardization includes the determination of working limits suitable for different kinds and sizes of gears and methods for testing and inspection.

The association has formulated plans for obtaining, from gear manufacturers and others interested in the design and production of gearing, suggestions and data relating to the subject, and the committees will digest the information thus obtained and present reports which, in turn, will be sent to the various manufacturers for suggestions and criticism. The General Standardization Committee of the American Gear Manufacturers' Association (B. F. Waterman, Brown & Sharpe Mfg. Co., Providence, R. I., chairman) will welcome any suggestions from any users of gears, as the success of the undertaking depends largely upon the cooperation of all concerned. The importance of the subject and the desirability of standardization will commend itself to all mechanical men.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

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SPRINGFIELD GUN BORING MACHINE

This machine is adapted for boring tubes, jackets, and bands for field guns. It has a capacity for boring holes up to 7 inches in diameter by 21 feet in length. The gun parts bored on this machine are made of chrome-nickel steel, and working in this tough heat-treated material the machine has a capacity for boring at the rate of 2 to 3 inches per minute.

IN the accompanying illustrations are shown four views of a large gun boring machine made by the Springfield Machine Tool Co., 631 Southern Ave., Springfield, Ohio, for boring field gun tubes, jackets, and bands. These parts are all made from chrome-nickel steel, which is very tough when heat-treated and has a high elastic limit. Naturally a powerful machine is required to bore such material. This Springfield gun boring machine is 28 feet long, and the headstock has a hole through the spindle which is 15 inches in diameter. The machine has a capacity for boring holes up to 7 inches in diameter and up to 21 feet in length. It will be seen that the machine consists of a bed with a headstock at one end, that is driven by a thirty-five-horsepower variable-speed motor, from which power is transmitted to the rear of the headstock by means of a silent chain drive running in a bath of oil and thence through a train of gears to the spindle. These gears afford four mechanical changes of speed, and they are made of chrome-nickel steel, heat-treated and hardened, with the exception of the large gear directly back of the chuck, which is made of high-carbon vanadium steel. With the variable-speed motor having a range of speeds of from 500 to 1500 revolutions per minute, and the four mechanical changes in the headstock, spindle speeds are available covering a range of from 20 to 200 revolutions per minute.

On large drills used in this machine, the thrust is enormous, and in order to support this thrust load, there is placed directly behind the chuck a large thrust bearing containing balls one inch in diameter, on which the entire pressure of the drill is supported. To insure proper lubrication of the spindle, which is 18 inches in diameter, it was found necessary to employ a forced-feed system of lubrication to insure the delivery of a steady stream of oil over all working parts in the headstock. The carriage and apron are of special design to provide for carrying the drill forward at varying speeds. Some idea of the conditions which had to be met in building this gun boring machine will be gathered from the fact that it is sometimes necessary to apply a pressure on the drill as great as 50,000 pounds. Feed is transmitted to the carriage through a long feed-rod, which will be seen in the front view of the machine, Fig. 1, and then through a system of gearing consisting of a worm and wheel, spur gears, and a rack and pinion. The total gear reduction amounts to 2400 to 1.

A handwheel is provided in front of the carriage for use in securing a small movement forward or backward, but for longer movements a quick-return mechanism is furnished at the back of the carriage, which will be seen in the rear view of the machine, Fig. 2. In the close view of the carriage shown in Fig. 3, the center lever is the quick-return lever, while the long lever at the front of the apron is a power feed lever. The handle to the right, pointing vertically, is the interlocking lever which prevents the quick-return mechanism from

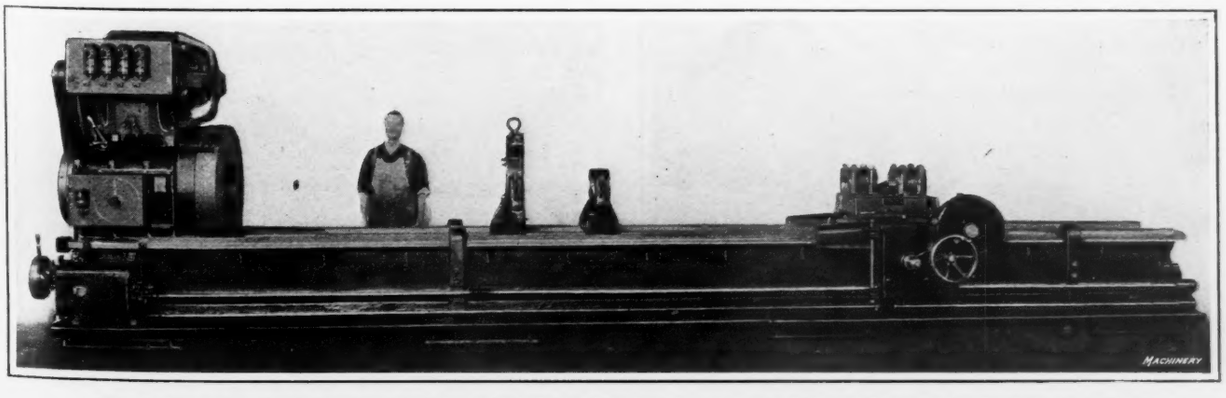


Fig. 1. Large Gun Boring Machine built by Springfield Machine Tool Co. for Use in boring Field Gun Tubes, Jackets, and Bands

being engaged while the feed mechanism is in operation. The handle to the left, which will be seen pointing vertically, is for operating the electrical mechanism that controls the motor, and is used for starting and stopping the main driving motor. In this illustration there will also be seen a large saddle which carries the drill. In the rear view of the machine shown in Fig. 2, a better idea is given of the arrangement of the quick-return mechanism and the means for furnishing cutting lubricant to the drill.

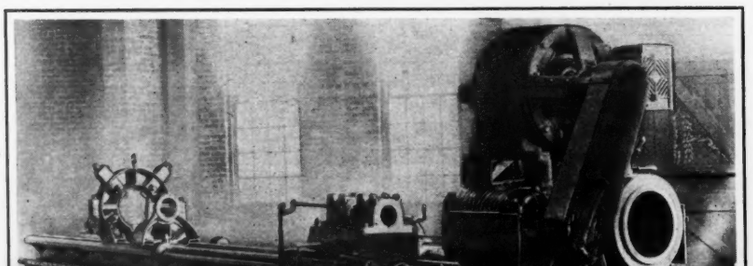


Fig. 2. Opposite Side of Springfield Gun Boring Machine, showing Arrangement of Quick-return Mechanism

At the rear of the carriage there is a feed mechanism which causes the carriage to travel along the bed at a rate of 35 feet per minute, this result being accomplished by means of a double-threaded lead-screw which has a lead of 4½ inches. The box arrangement at the back of the carriage supports two nuts, one of which has a right-hand and the other a left-hand thread, so that by engaging either one of these nuts with the screw, the carriage is caused to travel in one direction or the other, according to whether the right- or left-hand nut is engaged. Owing to the great length of the machine, it was found necessary to furnish the screw and rod with additional supports, the arrangement of which is clearly illustrated. The quick-return screw is driven by a three-horsepower motor, which will be seen at the rear of the machine, power being transmitted from this motor to a jack-shaft, which, in turn, drives the quick-return screw. This jack-shaft also transmits power to a large rotary pump capable of delivering 26 gallons of cutting compound per minute under a pressure of 100 pounds per square inch. One of the worst conditions to contend with in drilling especially deep holes is the necessity of carrying away the chips, which is accomplished by delivering a light liquid, such as a water cutting solution, to the point of the drill. This serves to keep the drill cool and in its backward flow carries the chips out of the hole in the work. As the carriage travels along the bed, it requires a constantly increasing or decreasing length of tubing to conduct this lubricant to the rear of the drill, and this is accomplished by a system of telescopic brass tubes, each of which has packed joints, so that provision is made for carrying the lubricant without leakage. In the rear view of the machine shown in Fig. 2, there will also be seen the provision made for forced lubrication of the various journals.

Power for driving the feed mechanism is transmitted from an intermediate shaft in the headstock to a two-step cone pulley by means of a silent chain drive, and from this point it is carried to the front of the machine to a gear-box located directly behind the controller on the front left-hand corner of the machine. This gear-box is furnished with gears that provide five rates of feed, and these are doubled by the two-step cone to give a total of ten available feed changes for the carriage, covering a range from 0.0015 to 0.016 inch per revolution. It will be seen that the entire machine stands in a steel pan, which catches all the chips and drilling compound and returns the compound to the reservoir ready to be delivered again to the drill point. To provide for handling the heavy work for which this machine is intended, it has to be heavily constructed. Exclusive of the electrical equipment, the weight is 28,000 pounds, and with the electrical apparatus added, the weight is brought up to 31,000 pounds. It will be of interest to note that the largest casting in the machine is the bed casting, which weighs 14,000 pounds, and also that all castings were made at the plant of the Springfield Machine Tool Co. In operation, the machine is capable of drilling large holes at the rate of from 2 to 3 inches per minute.

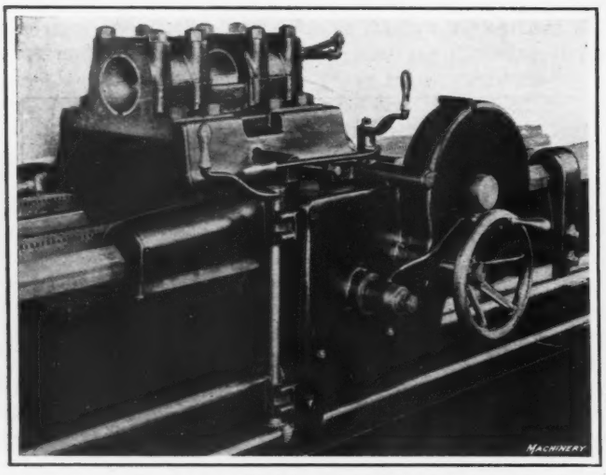


Fig. 3. Close View of Carriage of Springfield Gun Boring Machine

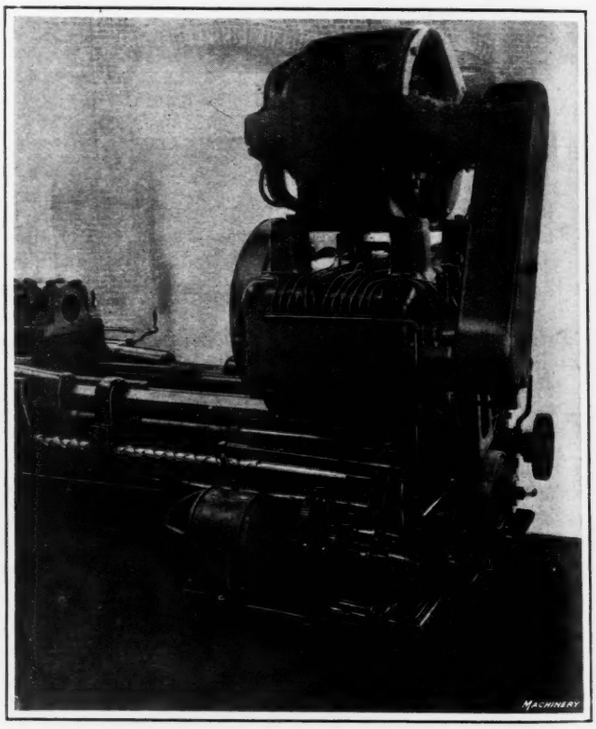
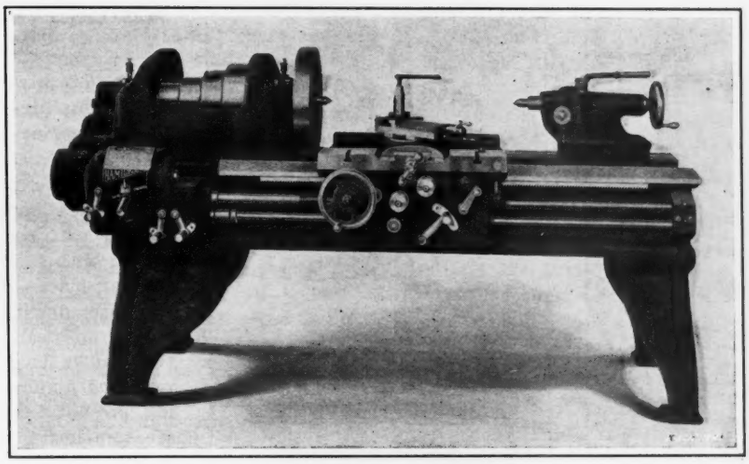


Fig. 4. Close View of Headstock of Springfield Gun Boring Machine

HAMILTON ENGINE LATHE

The 16-inch engine lathe with a cone head and quick-change gear, which forms the subject of this description, is one of the recent products of the Hamilton Machine Tool Co., Hamilton, Ohio. The bed is made of semi-steel, and the side walls are reinforced and secured by cross-braces at frequent intervals. One vee and one flat way are provided at the front of the bed and two vees at the back, the outer one being of extra width and extending well out from the front in order to afford plenty

of support for the carriage when the lathe is machining work of large diameter. The headstock is of box construction, with the sides extending up to the center line of the spindle; in this way, the front and rear bearings are tied together, causing the spindle thrust to be taken by both bearings and practically eliminating spring and vibration. The usual equipment of the headstock consists of a four-step cone pulley and single back-gears. An improved locking device permits the cone pulley and face gear to be instantly connected or disconnected without requiring the use of a wrench. The hollow spindle is made of chrome-nickel steel and the spindle bearings are lined with phosphor-bronze. These bearings are scraped to fit the spindle accurately and they are provided with sight-feed oil-cups. End thrust of the spindle is taken on a special ball bearing supported against the inside of the rear spindle box.



Sixteen-inch Engine Lathe built by Hamilton Machine Tool Co.

The tailstock is secured by two clamping bolts extending to the top, where they may be conveniently reached by the operator. The tailstock spindle is graduated in eighths of an inch and it is also provided with a micrometer dial which permits fine adjustments to be made. Provision is made for setting over the tailstock for the performance of taper-turning operations, and graduations indicate both the central position and the amount of set-over. A flat surface is provided on top of the carriage, which is furnished with T-slots so that work can be clamped to the carriage if so desired. The compound rest is furnished with taper gibs in both the top and bottom slide. A chasing dial is provided which facilitates the performance of thread-cutting operations. This dial is set flush with the carriage at the right-hand side and is so arranged that it may easily be disengaged when not in use, thus avoiding unnecessary wear. The apron is of box construction, the double walls supporting all shafts at both ends. Bronze bushings are provided for the shaft bearings and all gears in the apron are made of steel. Provision is made to prevent the feed and screw-cutting mechanisms from being engaged simultaneously. Both the longitudinal and cross feeds are friction driven and they may be easily engaged or disengaged.

All of the gears in the quick-change mechanism are made of steel and they are hardened and ground from the pitch line. This gear-box is a compact self-contained unit with provision for easily obtaining any desired rate of feed. Forty-eight changes of feed are available with regular set-ups, and the open-end lead-screw enables provision to be made for cutting any thread by the use of extra gears. In working out the design of this lathe, particular care has been taken to provide for convenience of operation. Quick-action handles are provided on the tailstock screw, the apron handwheel, and the cross-feed screw; and central oiling devices are provided on the apron and the quick-change gearbox, thus facilitating lubrication and assisting in keeping the bearings free from dirt. All oil-holes are protected by suitable covers and all gears are enclosed. The regular equipment furnished with the lathe includes a compound rest, double friction countershaft, large and small faceplates, a steadyrest, centers, and wrenches. Double back-gears, taper attachment, relieving attachment, cabinet legs, turret, oil-pan, etc., may be furnished as special equipment.

The principal dimensions of this lathe are as follows: swing over ways, 18¼ inches; swing over compound rest, 11¾ inches; capacity between centers for 6-foot bed, 36 inches; dimensions of front spindle bearing, 3⅛ by 5¼ inches; dimensions of rear spindle bearing, 2½ by 3¾ inches; diameter of hole through spindle 1½ inch; ratio of back-gear, 10 to 1; maximum traverse of tailstock spindle, 10 inches; diameter of tailstock spindle, 2 1/16 inches; range of spindle speeds, 6½ to 450 revolutions per minute; capacity for thread cutting, 2 to 112 threads per inch, including the 11½ per inch pipe thread; length of carriage bearing on ways, 27 inches; size of tools, 5/8 by 1 inch; capacity of steadyrest, 5½ inches; dimensions of countershaft friction pulleys, 12 by 4⅜ inches; speeds of countershaft, 154 and 190 revolutions per minute; and weight of machine with 6-foot bed, 3480 pounds.

GRAY SHELL MACHINERY

In the accompanying illustrations are shown machines built by the Gray Machine Tool Co., Inc., 2665 Main St., Buffalo, N. Y., for use in the performance of various operations involved in the manufacture of shells. In Fig. 1 is shown a machine designed for use in milling the threads in the nose or base of 6-inch high-explosive shells, and this machine provides for trimming the fuse seat or plug recess at the same setting of the work, thus making these surfaces perfectly true with the threaded hole. On 6-inch shells it is stated that the actual threading time is 1¼ minute for the 2-inch fuse hole, and 2½ minutes for the base plug recess. The work and cutter are rotated by separate belts from a countershaft. In performing a thread-milling operation on this machine, the lead of the thread is governed by moving the work-spindle endwise as it revolves. For this purpose, a threaded sleeve on the spindle runs in a nut which is held in a stationary position. During the facing operation this nut is locked to the spindle and revolves with it. To traverse the spindle endwise the nut is revolved in the reverse direc-

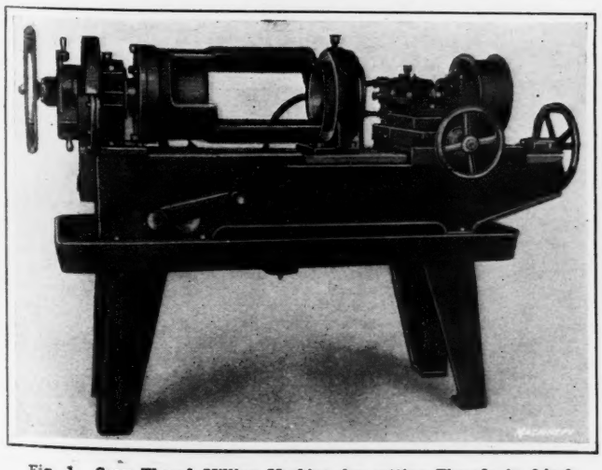


Fig. 1. Gray Thread Milling Machine for cutting Threads in 6-inch High-explosive Shells

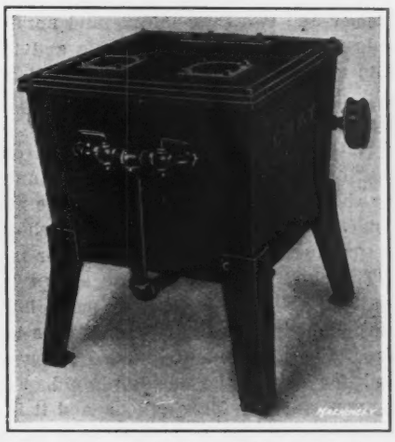


Fig. 2. Gray Shell Washing Machine furnished with Rotary Pump

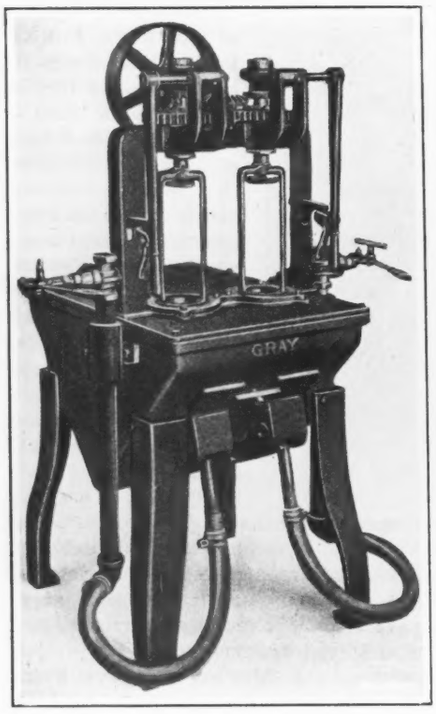


Fig. 3. Gray Shell Blast for alternately loading and cleaning Inside of 75-millimeter Shells

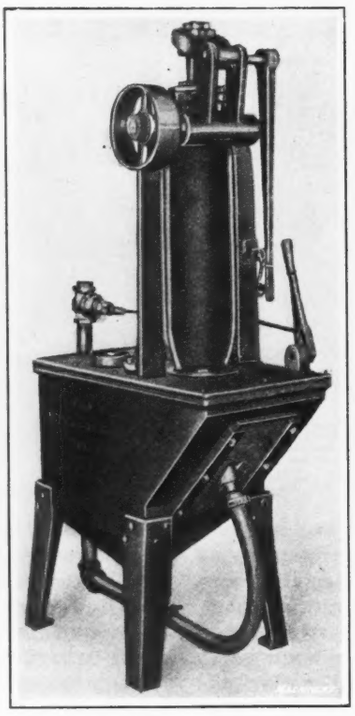


Fig. 4. Gray Shell Blast for cleaning Inside of 4.5-, 5-, 6-, and 8-inch Shells

tion, the work-spindle bearings are extended to allow a traverse of 2½ inches, and the direction of rotation of the work-spindle is such that the work travels away from the cutter.

In Figs. 3 and 4 are shown two forms of shell blasting machines which are especially adapted for cleaning the inside of shells with steel grit or steel shot. This treatment removes any signs of scale or boring-tool marks from the inside of nosed-in shells. The method of operation of both machines is essentially the same, so that the following description will give a good idea of the way in which either one operates. A shell is placed in the holder with its nose downward in a cup, after which the long lever handle is released to let the shell and holder drop down so that the blast nozzle is inside the mouth of the shell. This results in automatically engaging a clutch which causes the shell-holder to be slowly revolved. Then by pulling the short lever, a quick-opening gate valve on the air-line is opened, with the result that a specially arranged injector draws up the steel shot from the hopper and discharges them into the shell. After a few revolutions, the air is shut off and the long lever is pushed down, thus raising the shell and disengaging the clutch drive. The machine is said to be practically dustproof and the production from thirty to fifty shells per hour. The machine shown in Fig. 4 is suitable for cleaning 4.5-, 5-, 6-, and 8-inch shells and could easily be arranged for other sizes.

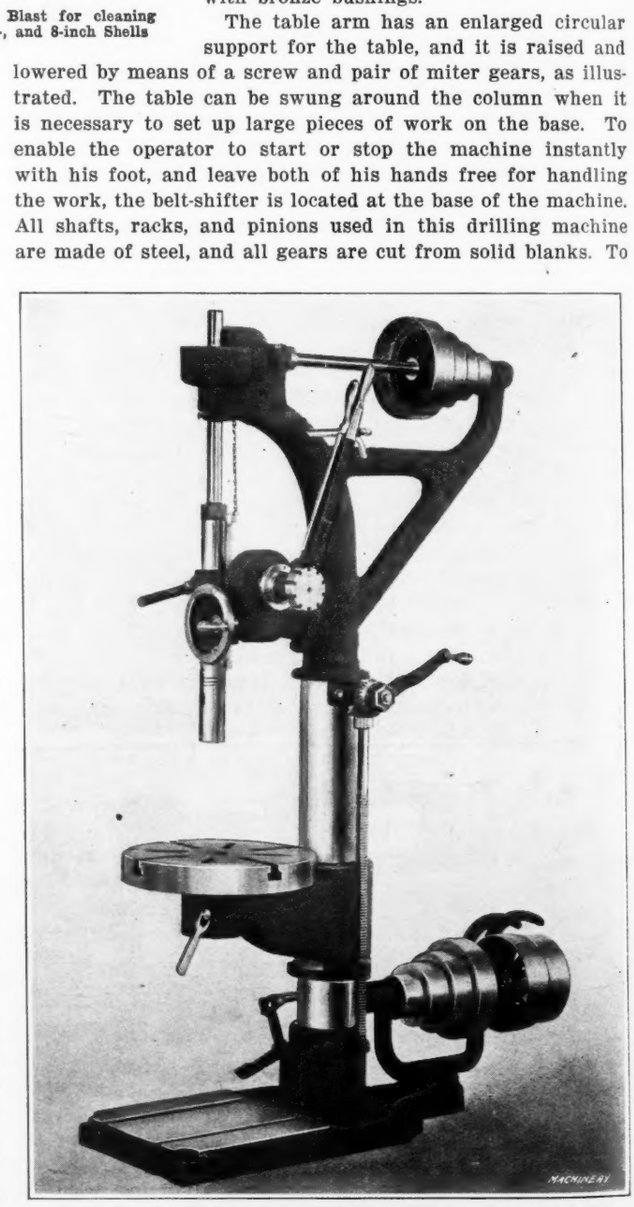
The machine shown in Fig. 3 is designed with a large hopper and two shell-holders and nozzle arrangements to provide for rapidly removing scale and tool-marks from the inside of 75-millimeter shells. A shell is placed in one holder and dropped into position to start the blasting operation. Then a shell is placed in the second holder and by the time that the operation has been started on the second shell the first one has revolved a few times and is ready to have the air shut off and be removed from the machine. The two shell-holders are run independently of each other. On this machine the production is said to be sixty or more shells per hour.

The shell washing machine shown in Fig. 2 is a cast-iron tank furnished with a rotary pump bolted to the back of the tank and piped to the two shell cups in the cover. When desired, the shell manufacturer can put a steam coil into the tank for heating the washing liquid. The capacity of the tank is approximately forty gallons, and it is divided into two compartments, so that only water can get back to the pump, the dirt and chips remaining in the first compartment. This machine handles shells up to 6 inches in size.

WEIGEL VERTICAL DRILLING MACHINE

The 20-inch wheel and lever feed vertical drilling machine illustrated is a product of the Weigel Machine Tool Co., Peru, Ind. It will be seen that this machine is built with a square base, which is of ample size and well ribbed underneath. It will also be noticed that the base is planed and furnished with T-slots to provide for bolting work in place. Split bearings are used for the upper driving shaft to afford means of taking up wear, and it will be seen that the head is fixed to the column. The feed rack and pinion, as well as all other gearing, are cut from solid blanks, and means are provided for taking up any wear of the spindle. This spindle is made of steel and finished to size by grinding. It has a drift slot through the nose, and quick approach and return movements are imparted to the spindle by means of the rack and pinion operated by a short lever at the left-hand side of the spindle. Ball bearings are employed to take the end thrust. The spindle sleeve is accurately finished by grinding, and it is graduated and fitted with bronze bushings.

The table arm has an enlarged circular support for the table, and it is raised and lowered by means of a screw and pair of miter gears, as illustrated. The table can be swung around the column when it is necessary to set up large pieces of work on the base. To enable the operator to start or stop the machine instantly with his foot, and leave both of his hands free for handling the work, the belt-shifter is located at the base of the machine. All shafts, racks, and pinions used in this drilling machine are made of steel, and all gears are cut from solid blanks. To



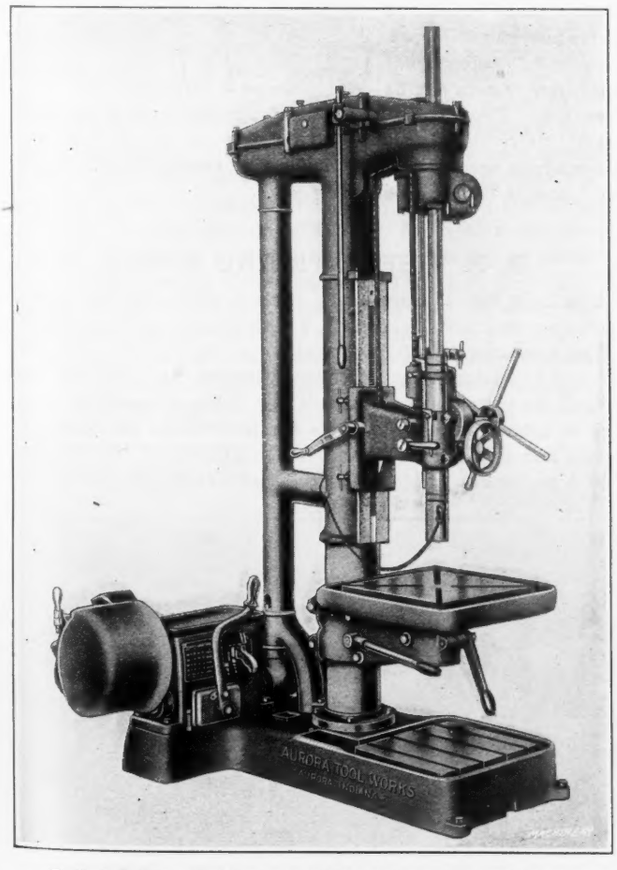
Vertical Drilling Machine with Wheel and Lever Feed built by Weigel Machine Tool Co.

avoid accidents, all gears are covered by guards. Accurate alignment between the table and spindle is assured by having the hole in the table arm bored by the drilling machine after it has been assembled.

The principal dimensions of this machine are as follows: total height with spindle extended, 6 feet 3¾ inches; height to top of cone pulley, 5 feet 10¾ inches; maximum capacity between spindle and base, 37½ inches; maximum capacity between spindle and table, 19⅜ inches; maximum traverse of spindle, 8 inches; maximum traverse of table on column, 17 inches; diameter of spindle, 1 5/16 inch; diameter of spindle in sleeve, 1 7/16 inch; diameter of sleeve, 2¼ inches; diameter of column, 5½ inches; diameter of table, 16½ inches; diameter of large step on cone pulley, 9 inches; diameter of small step on cone pulley, 4 inches; face width of cone pulley steps, 2¼ inches; dimensions of tight and loose pulleys, 9 inches in diameter by 3¼ inches face width; speed of lower shaft, 600 revolutions per minute; and approximate weight of machine on skids, 750 pounds.

AURORA TOOL WORKS VERTICAL DRILLING MACHINE

An important feature of the design of the 28-inch friction back-geared drilling machine which has recently been placed on the market by the Aurora Tool Works, Aurora, Ind., is that it has been designed with a thoroughly built-in construction. Every moving part, with the exception of the spindle and feed-rod, is enclosed, thus effectually excluding all foreign matter from moving parts of the mechanism and avoiding the possibility of injury to the operator. All bearings and gears are submerged in oil, and gage glasses show the oil level at all times, thus avoiding danger of the bearings or gears running dry. Ball bearings are used throughout the machine except in the quill. Another feature is the centralizing of all control levers and wheels, so that the operator is able to start or stop any movement, including clamping of the table and table arm, without leaving his position at the front of the machine. Every speed and feed is plainly marked and may be obtained for any size of drill without guesswork and without having to stop the machine.



Vertical Drilling Machine with Friction Back-gears built by the Aurora Tool Works

All spur gears are made of nickel alloy steel and heat-treated. They are of the cut spiral stub-tooth type, with a 20-degree pressure angle, and run without vibration or noise. All bevel gears are of the spiral type. Both tight and loose pulleys on the speed-box are fully enclosed, and the loose pulley is equipped with an oilless bearing; this pulley is made considerably smaller than the tight pulley in order to slacken the belt tension when the machine is not running. Through this speed-box and the back-gears sixteen changes of speed are obtainable. The spindle is machined from a high-carbon steel forging; it is double-splined and furnished with ball thrust bearings. A large reservoir is provided from which a copious flow of cutting compound is delivered to the tool carried by the spindle. This reservoir is cast integral with the base of the machine, and the base is furnished with a deep oil-groove extending all the way around the T-slots, thus permitting bolts to be entered into the T-slots from either end and allowing a free passage through which the cutting compound can flow back to the reservoir. The vertical driving shaft passes up through the tubular back-brace, where it is effectually guarded. An Aurora improved friction tapping attachment can be furnished with this machine.

Type A "Dumore" Drilling Machine built by Wisconsin Electric Co.

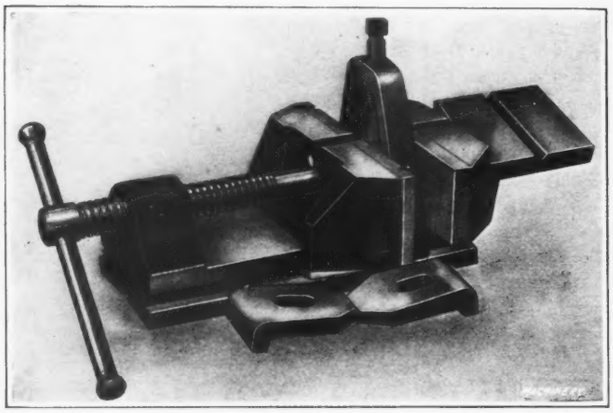
"DUMORE" ELECTRIC DRILLING MACHINE

The Wisconsin Electric Co., 1429 Dumore Bldg., Racine, Wis., are now building a "Dumore" Type A electric drilling machine which is suitable for the use of manufacturers and jewelers who require a sensitive drilling machine for handling light work. It will be seen that the machine is equipped with a direct-connected motor, which is of the variable-speed type. The machine is adapted for handling a wide range of drilling operations in steel, cast iron, brass, aluminum, fiber, hard rubber, etc. It is equipped with a No. 1 Jacobs chuck and a six-speed controlling unit which affords speed variations from 500 to 10,000 revolutions per minute, the available speeds being approximately 500, 2000, 4000, 6000, 8000 and 10,000 revolutions per minute. The controller is mounted on the floor and regulated by a foot-pedal. On this drilling machine the table is adjustable and gives the drill a stroke of ½ inch, the capacity of the machine being for drilling holes up to 1/16 inch in diameter in steel and 1/8 inch in diameter in soft alloys. Holes can be drilled to the center of a 5-inch circle. By carefully bringing the motor and drill chuck into accurate dynamic balance, smoothness of operation is assured.

G-S COMBINATION DRILL VISE

The Germanow-Simon Machine Works, 58 Mill St., Rochester, N. Y., are now building a combination drill vise which performs three distinct functions in that it combines a vise, V-blocks, and angle-plate in a single tool. The vise is of simple construction with the screw set above the center of the sliding

jaw to prevent wear on the bearings. This screw is of the square-thread type. The vees, cut across the top of the jaws and on the face of the sliding jaw, are always ready for work, and the work may be rigidly held in position in them. A special steel clamp provides for holding the work in the upper vees without the necessity of using straps and bolts. The angle-plate at the left-hand end of the vise can be set to any degree and held in place by tightening a single nut. The G-S combination vise is manufactured in two sizes, known as Nos. 1 and 2. The No. 1 vise has a base 12½ inches in length by 5 inches in width, and an extreme height of 5 inches. The size of jaws is 2½ inches in depth by 8 inches in width, and the jaws open 5 inches. The No. 2 vise is of similar design, but



Combination Drill Vise made by the Germanow-Simon Machine Works

of larger capacity and heavier construction. The base is 15½ inches in length by 7 inches in width, and the extreme height of the vise is 6 inches. The jaws are 3 inches in depth by 9 inches in width, and have a maximum opening of 7 inches.

TAFT-PEIRCE SQUARES AND V-BLOCKS

Knife-edge squares and V-blocks of the forms shown in the accompanying illustrations are recent additions to the line of tools made by the Taft-Peirce Mfg. Co., Woonsocket, R. I. It will be apparent that the squares are intended for use on work requiring a high degree of accuracy, and in order to fulfill this requirement each square is carefully hardened, ground, and lapped. It will be seen that the surplus stock is removed from the center of the tool to provide for inserting an insulation which affords a convenient grip and also decreases the weight

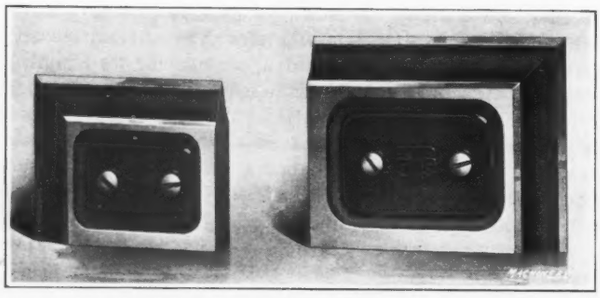


Fig. 1. Knife-edge Precision Squares made by Taft-Peirce Mfg. Co.

of the square. These tools are made in two sizes, namely, 2 by 2½ by 1/2, and 2½ by 3 by 9/16 inches, and each size is packed in a morocco leather case.

In Fig. 2 is shown the new Taft-Peirce V-block which is designed for holding cylindrical work for the performance of drilling and milling operations, etc. These blocks are made with a 3/4-inch hole through them, central with the sides and vee and square with the bottom surface. The hole is finished so that the block may be readily trued up on the faceplate, maintaining the vee central with the axis. Each side of the vee has three tapped holes for clamping screws, and as these holes extend entirely through the block, they can also be used for clamping it to a faceplate. Two clamps and four clamping screws are supplied with each block, and in the illustration one

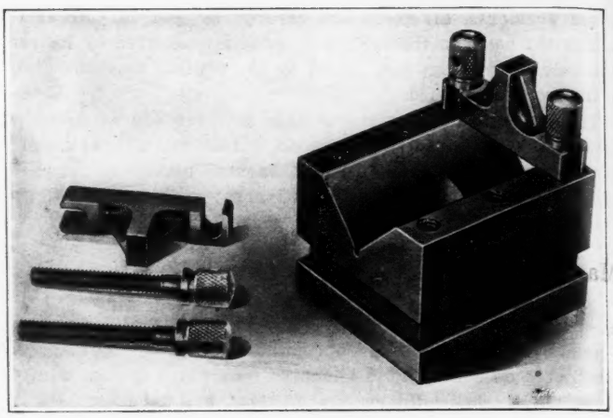
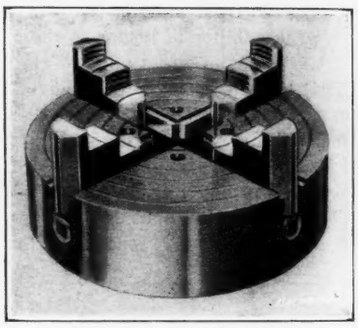


Fig. 2. Type of V-block now being made by Taft-Peirce Mfg. Co.

of these clamps is shown in position while the other clamp and its screws are shown lying beside the block. These clamps are so designed that they may be loosened or removed by one or two turns of each screw. A groove is milled all the way around the block to provide for strapping it in position, and each block is finished on all surfaces.

"NERCO" FOUR-JAW CHUCK

The Newark Engineering & Refrigerating Co., Newark, N. J., are now manufacturing a line of independent four-jaw chucks with iron bodies, the general design of which is shown in the illustration which accompanies this description. The jaws furnished in these chucks are reversible to provide for holding work from either the outside or the inside, and for use in those shops where a three-jaw chuck is preferred, independent three-jaw chucks can be furnished. From the initials of the company's name the trademark "Nerco" has been adopted for this line of chucks, which are made in seven different sizes having capacities of 4, 5, 6, 8, 9, 10, and 12 inches, respectively.



"Nerco" Chuck made by Newark Engineering & Refrigerating Co.

H. P. WHEEL-TRUING TOOLS

The H. P. Co., 45 Fort St. E., Detroit, Mich., are now manufacturing the Nos. 1, 2, and 3 grinding-wheel truing tools which are shown in the accompanying illustrations. The No. 1 truer is equipped for precision grinding machines and has interchangeable shanks which fit any make of machine. This tool is intended to true wheels for performing all classes of rough and semi-finished grinding operations. It will be seen that a grease cup is provided, which affords forced lubrication,

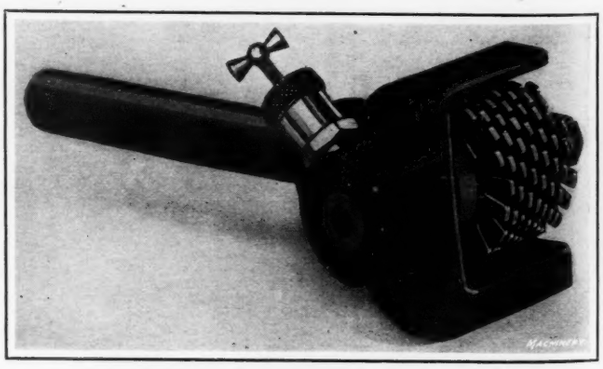


Fig. 1. No. 1 Wheel-truing Tool made by H. P. Co.

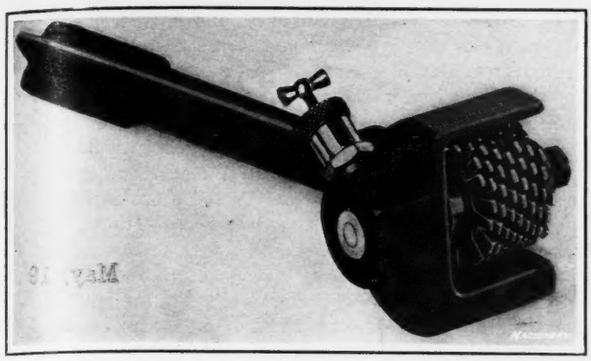


Fig. 2. No. 2 Wheel-truing Tool made by H. P. Co.

and the bearings are designed in such a way that dust and particles of abrasive are effectually excluded. The H. P. No. 1 truing device is being used successfully for truing grinding wheels used for rough-grinding crankshafts and camshafts, axle shafts, and other classes of lighter work.

In Fig. 2 is shown the No. 2 truing device which is intended for hand use only. It is furnished with the same form of cutter as the tool shown in the preceding illustration and either new or partially worn cutters may be employed in this tool. The head is of identically the same design as that of the No. 1 tool, the only difference being in the shank, which is so formed that it may be conveniently held in the hand. This shank is furnished with thoroughly lubricated bearings which are dustproof and waterproof. It is stated that when this tool is equipped with a new set of cutters, it will give 1500 dressings before being worn out.

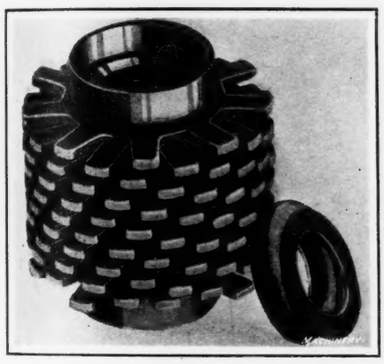


Fig. 3. Improved Abrasive Wheel Cutter used on H. P. Truing Tools

The improved abrasive wheel cutter used on both of these tools is 1⅝ inch in diameter by 1 inch face width. It consists of individual cutters mounted on a hub with the teeth so arranged that they form spirals. Each tooth is separate, so that it provides a distinct cutting point, and each cutter is mounted on a shaft which fits into the bearing in the shank. The cutters are hardened and ground to fit the hub. When the cutter is worn out, the shaft is withdrawn from the holder and each new cutter is equipped with a new shaft on which it is assembled and tested before being shipped. The only assembling necessary in the user's shop is to pull out the old shaft and substitute the one carrying a new set of cutting points. Guards are provided to protect the operator from possible breakage of cutters or from being struck by particles of the wheel.

On the No. 3 H. P. abrasive wheel-truing tool which is shown in Fig. 4, double adjustable bearings are provided and the truing tool is equipped with a set of cutters made of thin metal, which have been specially treated. The teeth are sharp and close together to give a smooth sharp surface to the wheel.

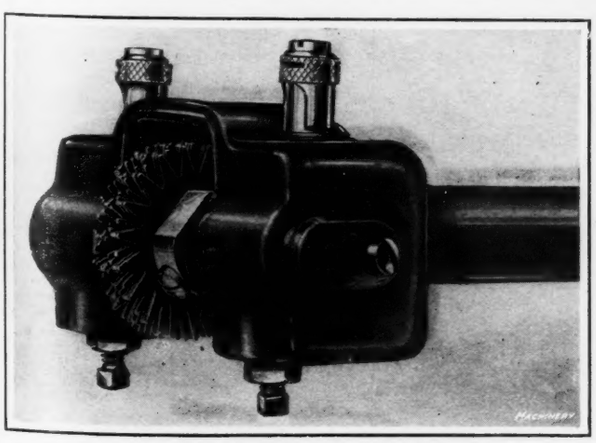
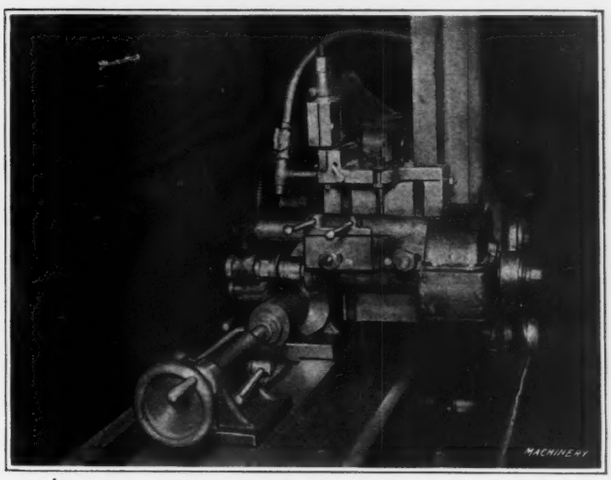


Fig. 4. No. 3 Wheel-truing Tool made by H. P. Co.

ATTACHMENT FOR BILTON MILLING MACHINE

The Bilton Machine Tool Co., Bridgeport, Conn., have added an attachment to their milling machines whereby the work feed is dependent upon the movement of the cutter. They have experienced considerable trouble in the past with work of the nature which requires the use of a fine saw. In the old-style Bilton milling machine a single-belt drive is used; and if by chance the cutter becomes broken or caught in the work, the table continues to feed and causes no end of trouble. To overcome this difficulty the belts that drive the feeding mechanism have been placed on the same shaft as the belt which drives the cutter-spindle. Having the feed belt connected with the belt that drives the cutter-spindle causes the feed to stop when the cutter-spindle gets stuck.



Attachment for Bilton Milling Machine which makes Feed Movement Dependent upon Cutter Rotation

WETMORE TAPS AND REAMERS

Since the first contracts for munitions were let in this country, there have been a great many developments in such special tools as taps, reamers, thread-milling hobs, and gages required in the production of munitions of war. In the accompanying illustrations are shown two forms of taps and an expanding reamer of the floating type for finish-sizing the fuse holes in shells. These tools represent additions to the line of products of the Wetmore Mechanical Laboratory Co., Milwaukee, Wis. In designing these special taps, shown in Fig. 1, advantage has been taken of experience gained in making taps to meet the requirements of a variety of different shell manufacturers, and thread forms have been chosen which have given the longest life and the greatest degree of accuracy. They are made of a special alloy steel.

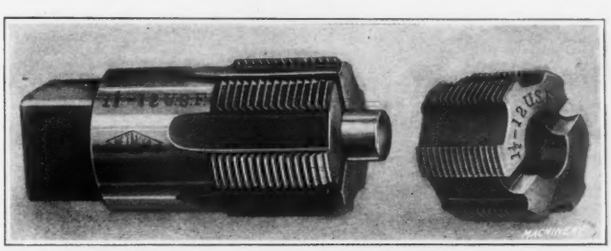


Fig. 1. Solid Hand Sizing Taps made by Wetmore Mechanical Laboratory Co. for Use in Fuse Holes of Shells

The expanding reamers are of the floating type, and the one shown in Fig. 2 is made to fit a 3-inch turret hole and is used for finish-sizing fuse holes of 155-millimeter United States Army shells. This reamer floats freely in its socket, is self-

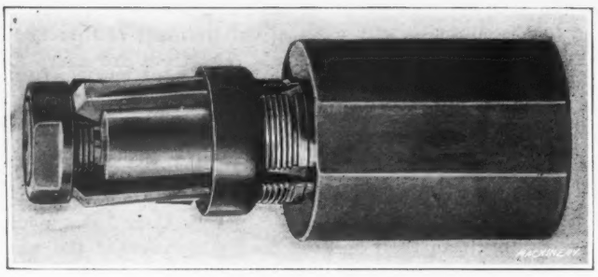


Fig. 2. Wetmore Expanding Reamer for finish-sizing Fuse Hole and Shoulder

centering, and assures the reaming of a true round hole. The blades are set at an angle to facilitate smooth cutting action and to eliminate the liability of chatter. In order to take up wear of the blades, they are expanded by means of two ground nuts and the design of the reamer is such that the blades may be removed or replaced without taking the tool apart. A true center in the end of the reamer makes it possible to grind the blades in place if so desired. These reamers are shipped with the blades ground to the dimension required by the user.

NEW BRITAIN TOTE-BOX RACK

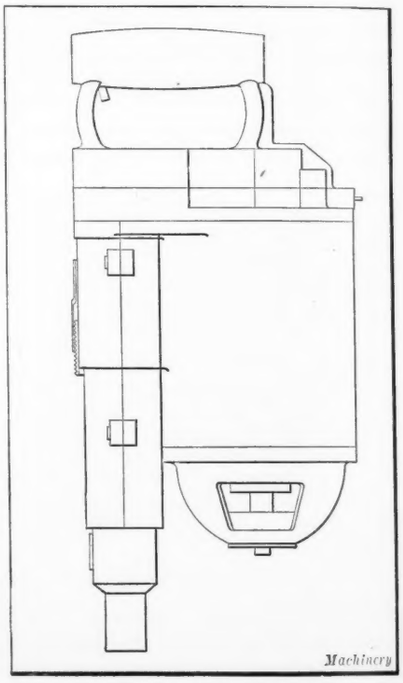
To meet the requirements of users of New Britain tote boxes who would find it convenient to store these boxes in a rack, the New Britain Machine Co., New Britain, Conn., have recently placed on the market racks of the form shown in the accompanying illustration. Based upon their experience with the uses which are made of tote boxes, the builders of this rack are of the opinion that it is universally adaptable to all requirements for small-parts storage. Although especially suitable for use in stock and assembling rooms, there are many other places in the factory where racks of this kind should be the means of saving time and money. The rack is of simple design and light weight, although it is so constructed that ample stiffness is provided to withstand practically any load that is likely to be placed upon it. The front uprights are made of flat steel and those at the rear are made of angles; angle runners upon which the boxes slide are electrically welded to each pair of uprights and these welded members are connected by cross-ties at the front, while the back is closed in and is stiffened by sheets bolted to the angle-iron uprights.

Rack for Tote Boxes made by New Britain Machine Co.

Racks of this type are commonly furnished in standard units as illustrated, although they may be expanded horizontally to any extent. Special racks may also be built to accommodate more than six boxes in each tier. Units are frequently placed back to back with a single sheet of metal between them. Particular attention is drawn to the safety feature which is clearly brought out in the illustration. When a box is pulled out, if the forward end is permitted to drop slightly, the raised rear end of the box will come into contact with the front cross-tie, thus permitting the box to be loaded or unloaded in this exposed position without any danger of its sliding out. A complete description of the New Britain tote boxes used in this rack was published in MACHINERY, November, 1916.

PAYNE & WILES ELECTRIC HAMMER AND DRILL

The Payne & Wiles Machine Co., 302-308 S. Ninth St., Lincoln, Neb., are now manufacturing a combination electric hammer and drilling tool. In working out the design, care has been taken to simplify the mechanism as far as possible and reduce the number of parts to a minimum. The tool is adapted for the use of machinists, electricians, and in garages, etc. It is suitable for chipping castings, cutting holes through concrete floors, calking boiler seams, beading flues in boilers, drilling metal, etc. The weight of the tool is 11 pounds and it will drive drills up to 1/2 inch in diameter in steel or cast iron; chisels up to 1/2 inch may be driven by the hammer for keyseating, and chisels up to 1 inch can be driven for chipping iron and steel castings.



Payne & Wiles Combination Electric Hammer and Drill

A universal motor is used to drive the tool, which is adapted for connection to 110-volt alternating- or direct-current circuits, attachment being made to any lamp socket. Tools of this type can be made in different sizes ranging in weight from 3 to 100 pounds. The hammer and drilling spindle can be operated independently of each other, or the drill and the hammer can be run simultaneously. Patents have been granted on features of this tool to W. S. Payne of the Payne & Wiles Machine Co.

GLENZER COUNTERBORE AND SPOT-FACER

The "Utility" interchangeable piloted counterbore and spot-facer is a recent product of the J. C. Glenzer Co., Fort St., W., corner Fourteenth, Detroit, Mich. The manufacturers claim that the design of these interchangeable counterbores and spot-facers has been developed with a careful consideration of the

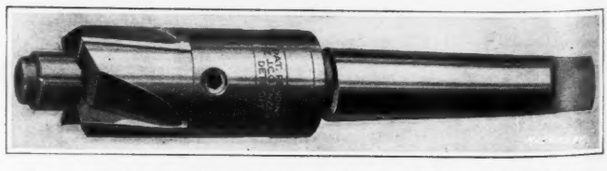


Fig. 1. "Utility" Piloted Interchangeable Counterbore and Spot-facer made by J. C. Glenzer Co.

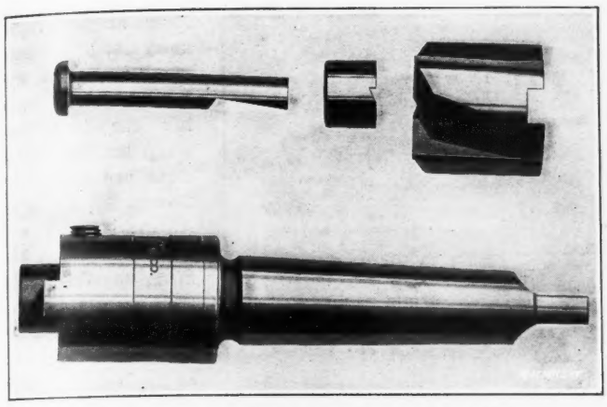


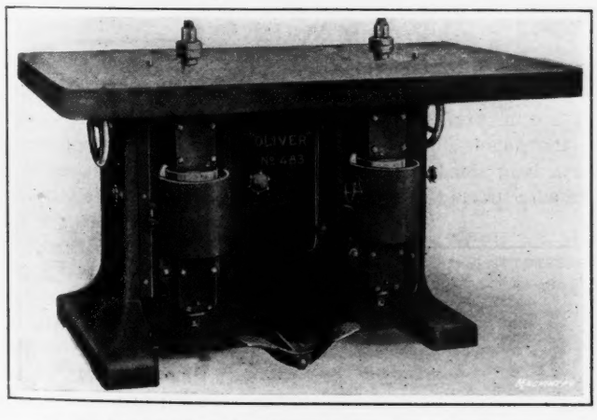
Fig. 2. Parts of "Utility" Counterbore and Spot-facer

actual requirements which tools of these types must fulfill under severe conditions of service. The cutter drive is of simple though powerful construction, and the cutters can always be quickly and easily removed. By having the pilot made in the form of a bushing and positively driven by the cutting edges of the cutter, all strain is relieved from the pilot pin.

These interchangeable counterbores and spot-facers are made with four different sizes of holders which have capacities for holding cutters from 3/8 to 3/4 inch, 3/4 to 1¼ inch, 1¼ to 2 inches, and 2 to 3 inches in diameter, respectively. The holders are heat-treated and accurately ground to size, and the cutters are made of high-speed steel. Pilot bushings are of standard 1/64-inch sizes, and they are made 0.008 inch under size. Cutters are made in 1/16-inch sizes, and holders with special tapered shanks or straight shanks can be made to special order.

OLIVER DOUBLE SHAPER

A No. 483 high-speed double shaper has recently been added to the line of woodworking machines built by the Oliver Machinery Co., 7 Coldbrook St., Grand Rapids, Mich. This machine is adapted for the performance of rabbetting, grooving, fluting, routing, or shaping operations. It is furnished with a large table which is planed and then ground to an accurate



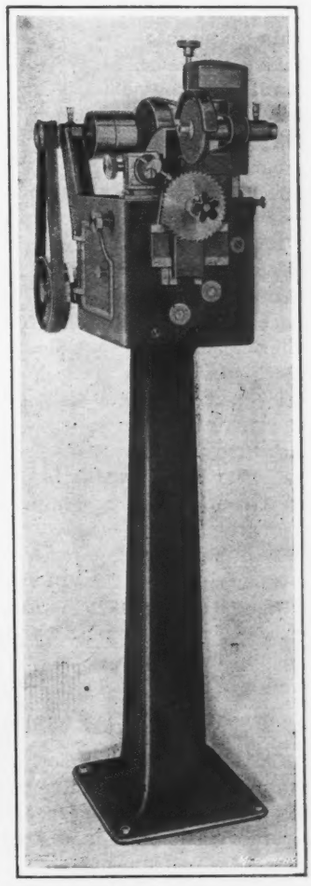
No. 483 High-speed Double Shaper built by Oliver Machinery Co.

finish. The spindles are made of high-carbon crucible machinery steel and are finished by grinding. They are supported in bronze conical-shaped bearings furnished with oil-chambers which lubricate the spindles for the entire length of the bearings. At the bottom of each spindle there is a copper adjustable step which is constantly washed with oil. Adjustments of the bearings are easily and rapidly made. As this machine runs at high speed, it is important to have the pulleys carefully balanced; they fit the spindles perfectly and are held in place by tapered pins.

A quick-adjusting shaper guard is furnished with each machine and additional guards may be obtained, as each table is drilled and tapped for two guards. These guards are adjustable in all directions, so that they do not interfere with the operation of the machine. When motor drive is used any of the following methods may be employed: Two separate motors may be furnished, one for driving each spindle; one motor may be direct-connected to the end of the countershaft by means of a coupling; or one motor may be employed with the shaft sufficiently extended to carry a suitable pulley at each end. An improved column type of countershaft fitted with independent belt tighteners and a ring type shifting device is furnished with each machine. The main pulleys are of the ring-oiling type and the loose pulley is bronze bushed and has an oil-chamber of ample size to insure efficient lubrication.

AUTOMATIC SLITTING SAW SHARPENER

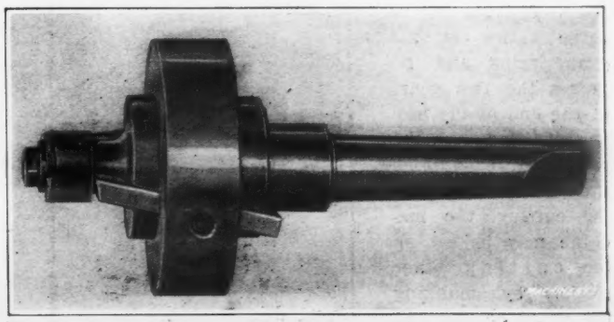
The Machinery Co. of America, 505 Sixth St., Grand Rapids, Mich., are now building a No. 10 automatic slitting or milling saw sharpening machine which will resharpen or recut saws with very little loss of time. It is stated that this machine will grind circular saws with the teeth all uniformly spaced and the circumference of the saw perfectly round. With the saw ground in this way, strains on the blade and danger of breaking the teeth are practically eliminated. The machine is adapted for sharpening or recutting saws from 2 to 10 inches in diameter with the usual spacing of teeth, and it is especially suitable for use in reclaiming very thin slitting saws with fine tooth spacing. The operation of the machine is fully automatic, requiring very little attention on the part of the operator after the work has been set up and the machine started. The machine is rigidly constructed and supported on a pedestal of substantial design, which brings the mechanism to a convenient height for the operator. All essential parts of the mechanism are enclosed in the body of the machine, where they are fully protected from abrasive dust and other foreign matter. Ample adjustment is provided for taking up wear in all moving parts. On this machine any standard shape or spacing of teeth may be readily obtained by means of handwheel adjustments, conveniently located for the operator.



No. 10 Automatic Slitting Saw Sharpening Machine built by the Machinery Co. of America

GENESEE FACING TOOL

For use in the performance of counterboring, facing, forming and similar operations, the Genesee Mfg. Co., Rochester,



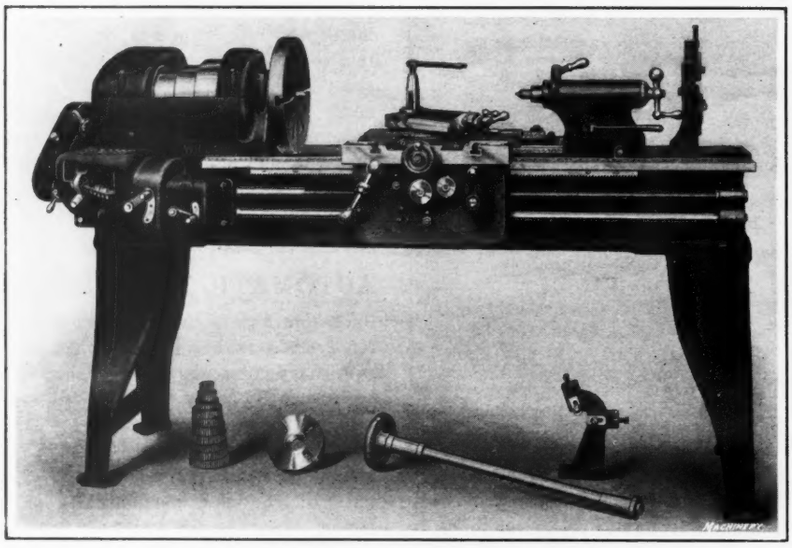
Facing Tool made by Genesee Mfg. Co.

N. Y., are now making the facing tool which is illustrated and described herewith. The blades can be sharpened without requiring the use of a special holder, and these blades are supported in such a way that the tool is adapted for securing the full productive capacity from high-speed steel. The design has been worked out along such lines that the chip clearance remains the same, regardless of the number of times the blades have been ground, so that their cutting efficiency remains uniform throughout the life of the blades. When it is required to use this tool in close corners, the heavy-duty ring is removed.

When grinding the blades it is simply necessary to remove them from the holder and grind in such a way that they will test up to a square. The tool is never removed from the machine, so that after the blades have been ground the only thing required is to slide them back against the bushing which locates each cutting edge in line and in the same position that the blades occupied before grinding. This method of grinding makes it unnecessary to readjust the machine each time the blades have to be sharpened. For cutting steel, malleable iron, etc., the blades are placed at an angle of 12 degrees, while for machining brass and other soft materials, they are placed in a radial position. The body of the tool is made of machine steel, casehardened, and is of ample strength to stand up under the full capacity of the power feed of any drilling machine. These tools are made in styles A and B with two and three blades, respectively, and each style is made in four different sizes.

WILLARD TOOL-ROOM LATHE

The Willard Machine Tool Co., of Cincinnati, Ohio, are now building the tool-room lathe which is illustrated and described herewith. The quick-change feed-box on this machine is a separate unit which is secured to the bed by means of four bolts, its alignment being assured by means of tongues planed to fit corresponding grooves in the bed of the machine. One lever on this box manipulates the tumbler gear and affords forty changes in connection with only one other lever, which engages one of three ratios in the gear trains and reverses the two gears at the end of the bed. In addition to the range of threads which the gear-box provides for cutting, the machine may be set up for cutting other pitches by changing the gears on the end of the bed. The third lever at the right-hand side of the feed-box is only to provide for disconnecting the lead-screw when turning operations are being performed on this lathe. All gears in the feed-box are made of steel, the only cast-iron gears being the two reversible driving gears at the end of the bed. All gears are supported at both ends and there are no overhanging studs. All shafts are made of 50-point carbon steel and they are ground to an accurate finish.



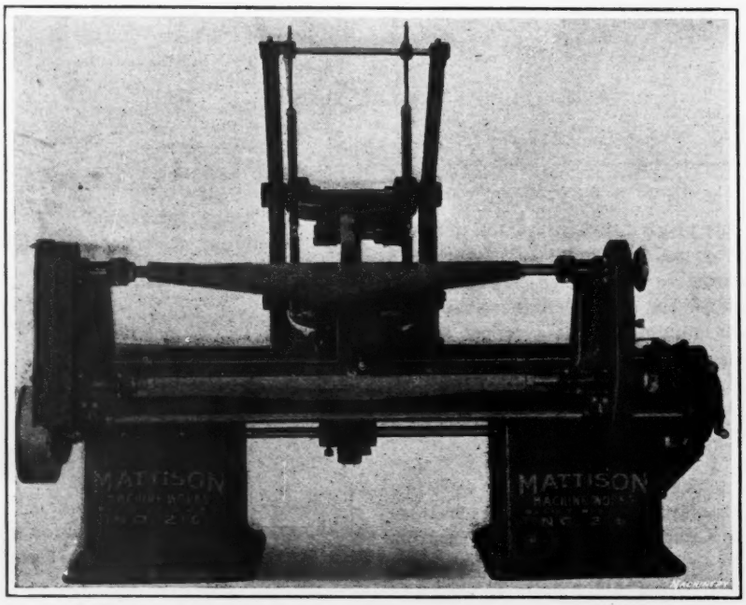
Tool-room Lathe built by Willard Machine Tool Co.

Since the Willard Machine Tool Co. took over the Willard Machine & Tool Co., the new management has been working on the improvement of the Willard lathe. The sides of the headstock have been brought up level with the center line of the spindle at both the front and rear, which assures greater strength and rigidity by tying the two spindle bearings together. The headstock has a bearing 21½ inches long on the bed of the machine, and it is furnished with a spindle made of 65-point carbon crucible steel, which is finished by grinding. The reverse gears are made of steel and the idler gears are bronze bushed. A bearing 18 inches in length is provided for the carriage on the vees of the bed, and this carriage is furnished with a bridge 7½ inches in width. All sliding surfaces are taper gibbed to provide a convenient means of compensating for wear, and all dials are of ample size to facilitate accurate reading. The vees on the bed of the machine are chilled to insure durability.

MATTISON AIRPLANE STRUT TURNING MACHINE

The copying lathe which forms the subject of this description is built by the C. Mattison Machine Works, Beloit, Wis., for use in turning airplane struts. Special attention is called to the double-end drive which is of exceptional importance when long slender stock, such as an airplane strut, is being turned. Driving from both ends avoids much of the tendency to twist the work and revolve it with a jerky motion. This double drive is also said to do away with trouble experienced from putting a "wind" in the work and producing a poor finish. The carriage is of the double rocker type, and the rocker arms which support the cutter-head and model wheel work without friction, thus insuring great sensitiveness and accuracy in operation.

Travel of the main carriage is backward or forward along the bed of the machine, so that no time is lost in shifting the carriage back to the starting point between succes-



Copying Lathe built by the C. Mattison Machine Works for turning Airplane Struts

sive operations. Quick-change gears are provided which give three rates of feed, any of which may be instantly obtained while the machine is running. A special cutter-head has been developed for use on this copying lathe, which is adapted for rapidly and smoothly cutting spruce wood. The rate of feed may be varied from 7½ to 30 inches per minute, depending upon the shape of the stock which is being worked. The standard lathe takes stock up to 6 feet in length, but special machines may be built to take longer pieces. The machine is entirely self-contained and may be driven either from an individual electric motor or from a countershaft. It occupies a floor space of 4 by 11 feet and weighs 4500 pounds.

MASON HIGH-SPEED DRILLING MACHINE

The A. C. Mason Co., Inc., Paterson, N. J., are now building a quick-change high-speed drilling machine of the bench type. In the accompanying illustrations is shown a single-spindle machine, but multiple-spindle drilling machines of this type are also being built. This machine is built on the unit plan with all parts of the mechanism readily accessible to facilitate making adjustments. Ball bearings are used throughout, and all exposed parts of the mechanism are guarded in a way which avoids danger of damage to the mechanism or injury to the operator. The mechanism and method of operation have been simplified as far as possible, thus making the machine well adapted for use by women employed in machine shops. On this machine, the design has been worked out in such a way that all changes of speed may be made without requiring the machine to be stopped. The cone pulley is made of a special fabric composition to reduce belt slippage and to make it unnecessary to maintain the belt under excessive tension.

A uniform belt tension is maintained by a spring idler pulley which also compensates for differences in length of the belt track. The rear vertical shaft is fully enclosed and driven by a two-speed geared drive. Either of the two available speeds is obtained by a semi-automatic clutch operated by a convenient handle. Power to drive the machine is carried by a belt which runs over a tight or loose pulley on the gear-box, the pulleys being fully enclosed. There is a total of four available spindle speeds ranging in geometrical progression from 3000 to 10,000 revolutions per minute. The back-shaft speed is 1800 revolutions per minute. The horizontal back-shaft is a unit with the gears and so is the vertical shaft, each one being removable without the necessity of disturbing adjacent parts.

The spindle pulley, together with its upper and lower bearings, is a complete unit which can be removed without requiring any other part to be disassembled. The design has been so arranged that the spindle is relieved of all belt pull. Semi-hardened steel of high elasticity is used in making the spindle, this material being capable of resisting blows resulting from jigs being slammed against the chuck, without danger of bending the spindle. The spindle and its bearings are a complete unit which may be removed from the sleeve without taking the sleeve or spindle pulley from their fastenings. A positive depth gage is provided for the spindle to facilitate drilling holes to a specified point. Continuous lubrication to all bearings connected with the spindle and the spindle bracket is accomplished by means of a simple oiling device which furnishes a continuous flow of lubricant. A balanced chuck suitable for holding drills up to 1/4 inch in diameter is provided with the machine, and the spindle has a maximum feed movement of 6½ inches. The pinion which governs the feed movement of the spindle may be operated from any position and is quickly adjusted to take up backlash between the pinion and the rack teeth cut in the spindle sleeve. A table of liberal proportions is furnished on the machine and it has a large channel running around its periphery to carry away lubricant or cutting compound.

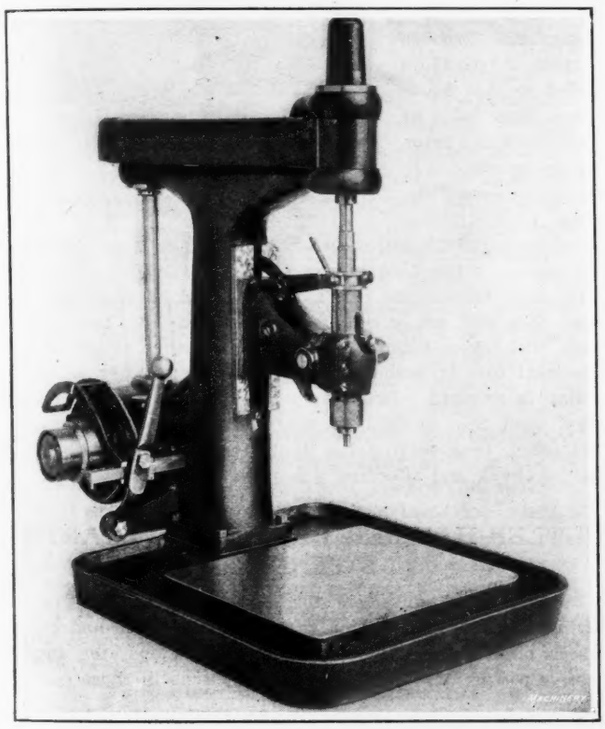


Fig. 1. High-speed Bench Drilling Machine built by A. C. Mason Co., Inc.

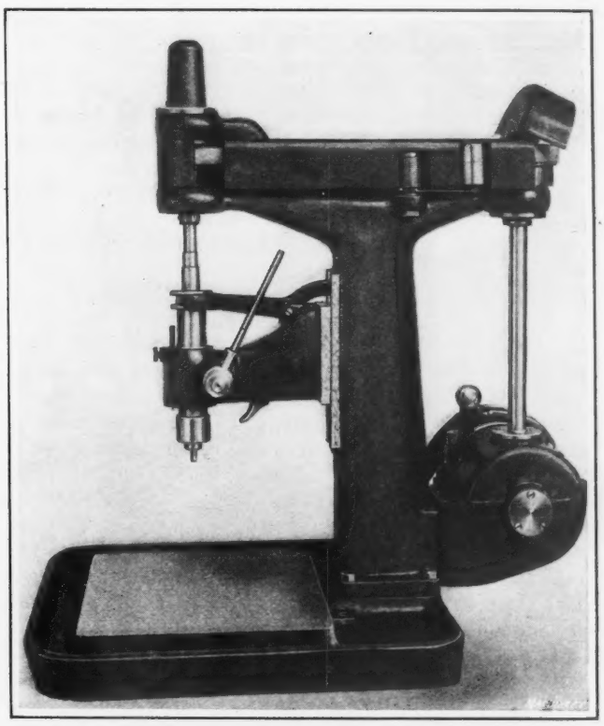


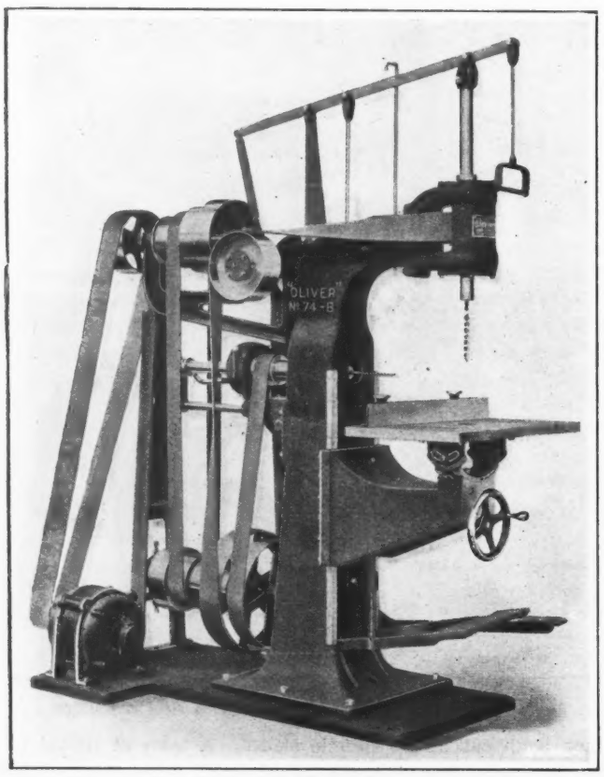
Fig. 2. Opposite Side of A. C. Mason Bench Drilling Machine

OLIVER WOOD-BORING MACHINE

One of the recent products of the Oliver Machinery Co., 7 Coldbrook St., Grand Rapids, Mich., is the No. 74 universal vertical and horizontal wood-boring machine which is shown in the accompanying illustration. This machine is adapted for all kinds of boring and it also operates efficiently in drilling holes in metal and in doing the work of a router, shaper, buzz-planer, or sanding machine. Both the vertical and horizontal spindles are mounted in ball bearings, and they can be fitted with a three-jaw chuck and a variety of bits, fly cutters, and such special cutters as little patternmakers, etc. Both spindles have a capacity for boring holes up to 3 inches in diameter; the vertical spindle will bore to a depth of 12 inches at the center of a circle 36 inches in diameter, and the horizontal spindle will bore to a depth of 7 inches at a height of 16 inches from the top of the table. This machine is built in two types known as the Nos. 74A and 74B, the first of which has only a single-speed self-contained countershaft. Either type of machine may be furnished with motor drive.

On these machines the vertical spindle is usually bored to take 1/2-inch straight shanks, but when so ordered, it may be threaded to receive a three-jaw chuck. The spindle is 1⅞ inch in diameter and slides in a sleeve formed by the driving pulley, which has extended ends carried by ball bearings. The vertical travel of this spindle is 12 inches and on the No. 74A machine the speed is 3000 revolutions per minute, while on the No. 74B machine the four available speeds cover a range of from 968 to 3450 revolutions per minute. The horizontal spindle is also ordinarily bored to take tools with straight shanks, 1/2 inch in diameter, but this spindle may also be specially equipped. It slides in a sleeve formed by the pulley, which is mounted in ball bearings. The horizontal travel of this spindle is 7 inches, this movement being accomplished by a foot-treadle, while return of the spindle is effected through pressure applied by a coiled spring. On both types of machines, the horizontal spindle speeds are the same as the speeds for the vertical spindle, which have already been given.

The table is 18 by 30 inches in size and has a vertical adjustment of 17 inches, which is obtained by means of a screw and handwheel. Angular settings of the table may be made up to 40 degrees toward or away from the column and 30 degrees



No. 74 Universal Vertical and Horizontal Wood-boring Machine built by Oliver Machinery Co.

to the right or left. Graduated scales are furnished to facilitate making the angular settings of the table. When motor drive is employed, either a 900 revolutions per minute constant-speed motor or a suitable adjustable-speed motor is employed on the No. 74A machine, and this motor is mounted on the baseplate in place of a countershaft. With the No. 74B machine, either an 1800 revolutions per minute constant-speed motor or a suitable adjustable-speed motor is mounted on an extension of the baseplate and belted to the upper driving shaft. The motors used must be from three to five horsepower, according to the service for which the machine is to be employed. The floor space occupied by the No. 74A machine is 70 by 38 inches, and the No. 74B machine occupies a floor space of 73 by 38 inches.

"CRESCO" DRILL CHUCK

The Chicago Recording Scale Co., Waukegan, Ill., are now building a quick-change drill chuck which is illustrated and described herewith. Features claimed for the design of this chuck are that no screws are employed to hold the parts together and that the chuck is ground on all surfaces; the chuck is said to be perfectly balanced, so that it will run without any tendency toward vibration. This chuck is of the quick-change type which is used in cases where different tools are required for the performance of a sequence of machining operations. Different tools to be held and driven by the chuck are carried in collets which have two tangential grooves cut on opposite sides so that hardened steel balls in the chuck can enter these grooves. It is unnecessary to stop the drilling machine spindle rotating in order to change tools; the operator simply takes hold of the collar on the chuck body and lifts it to release the two hardened steel balls so that they may drop back out of the grooves in the collet. This collet is then withdrawn from the chuck and another collet carrying the next tool is pushed up into the chuck, after which the collar is dropped. Dropping of the collar forces the hardened steel balls inward, so that they engage the grooves in the collet, thus serving the double purpose of holding it up in the chuck and affording a positive drive for the tool.

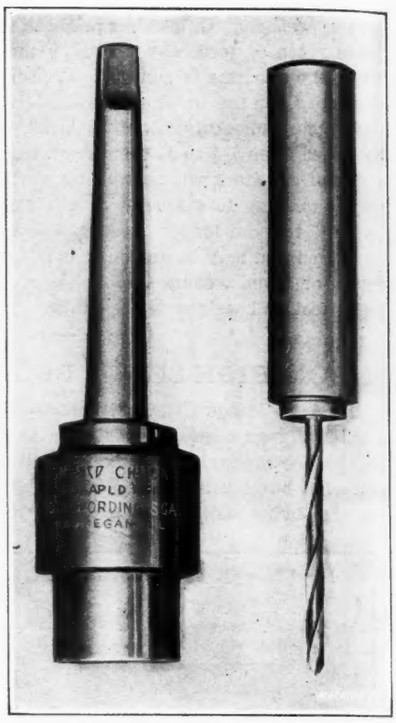


Fig. 1. "Cresco" Quick-acting Drill Chuck made by Chicago Recording Scale Co.

CUTLER-HAMMER DRUM TYPE STARTING SWITCHES

Purchasers of equipment for the modern factory are now giving special consideration to methods of drive and control which offer the greatest protection to the operator and the motive power; this has been especially true in those factories

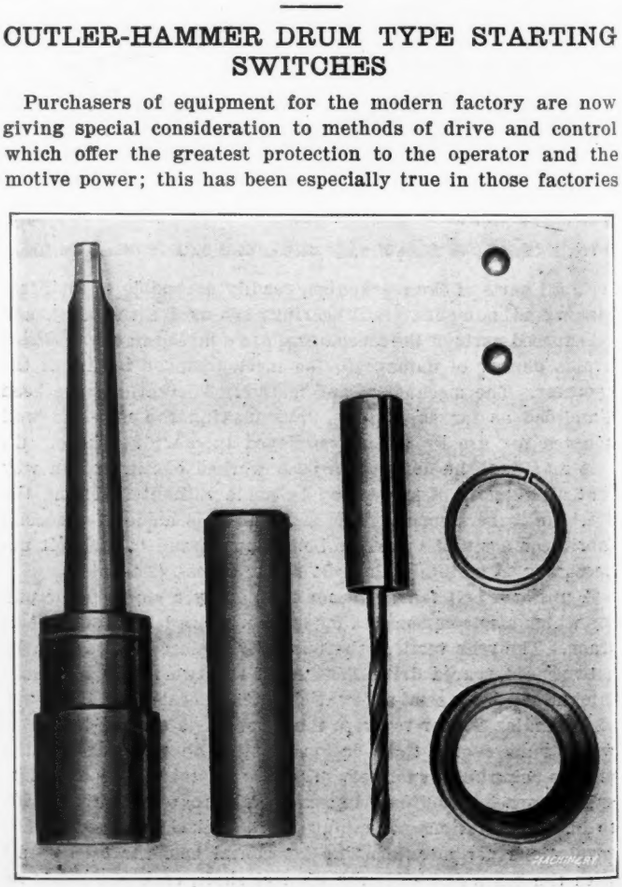
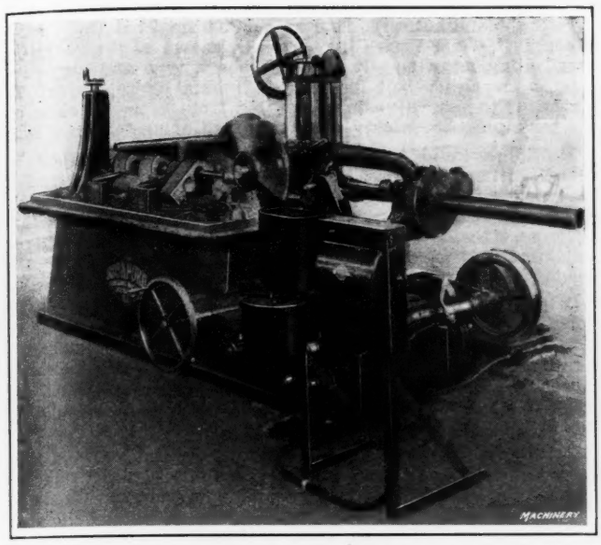


Fig. 2. Parts of "Cresco" Quick-acting Drill Chuck



Rockford Horizontal Drilling and Milling Machine equipped with Cutler-Hammer Drum Type Starting Switches for Individual Motor Drive

which have been built to meet the immediate demand for guns, ammunition and other war necessities. The accompanying illustration shows one of four oil-immersed starting switches controlling a five-horsepower squirrel-cage alternating-current motor, driving one of the Rockford Drilling Machine Co.'s horizontal drilling and milling machines in a gun factory in Wisconsin. These drum type switches are especially adapted for this and other machine shop installations because it is impossible for the workman to come into contact with any live part, and, furthermore, they offer a degree of protection to the motor not obtainable with knife switches and some other form of starting devices. These switches are built by the Cutler-Hammer Mfg. Co., Milwaukee, Wis., and follow the design of the well-known C-H drum type controller. Copper segments mounted vertically on a thermoplax cylinder carried on a square steel shaft engage three sets of contact fingers which have hard drawn copper tips that are renewable and non-snubbing. No moving leads are used, a terminal board being conveniently located in the top of the cover casting, the connections to which can be made very easily. This arrangement prevents the leakage of oil due to syphoning or capillary action. The switch shown in the illustration is furnished with enclosed fuses, although in some cases two inverse time element overload relays are substituted. All are provided with no voltage release.

When the handle is thrown to the "start" position the motor is connected to the line ahead of the fuses, and then connects the fuses in the circuit when thrown to the "run" position. Besides being smaller than many forms of starting switch, they are provided with large mounting lugs, permitting the switch to be secured to a machine or wall. This arrangement also permits the oil tank to be removed without disturbing the mounting or connections. The terminal board is provided with control circuit terminals, so that with the addition of a two-wire circuit and push-buttons the motor can be stopped from any desired position. This feature is especially desirable when the motor drives a large machine tool, conveyor or other machinery, where the danger of workmen being injured must be reduced to a minimum. On failure of voltage, overload, or when purposely released, the switch is returned to the "off" position by a strong coiled spring and the motor is entirely disconnected from the line. These switches are made for 110, 220, 440, and 550 volts, and can be used with any polyphase motor up to twenty horsepower. A similar switch is made for use with three-phase squirrel-cage motors.

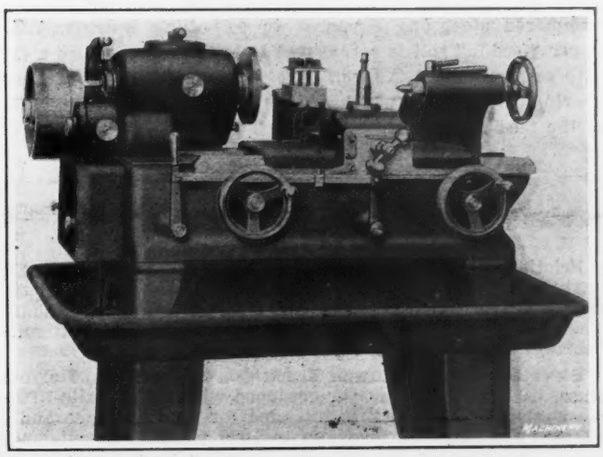
"SUNDSTRAND" MANUFACTURING LATHE

To meet the requirements of plants engaged in the production of large quantities of duplicate parts, the Rockford Tool Co., Harrison Ave. and 11th St., Rockford, Ill., have recently placed on the market the "Sundstrand" manufacturing lathe which is adapted for rapid production. This machine is simply designed throughout, so that the operation has been simplified; and ample power is provided to enable machining operations to be performed under the maximum conditions of speed and feed. As there are a great many lathe jobs performed on a strictly manufacturing basis, which consist of machining short pieces of comparatively small diameters, a compactly built lathe of this type effects a saving of approximately 50 per cent in floor space without in any way affecting the efficiency with which work can be handled that comes within the capacity of the machine.

The bed is of a new design, having separate ways for the tool carriage and the tailstock, the arrangement being such that the carriage can travel to the end of the bed in front of the tailstock. It will be apparent that this allows the tailstock to be set up close to the work, eliminating the overhang of the tailstock center. The bed is of deep section and ribbed to afford the necessary rigidity. An all-geared type of headstock is employed, which is operated by a sensitive friction clutch upon which the driving pulley is mounted. This clutch is manipulated by a conveniently located lever and the same movement that disengages the clutch automatically applies a friction brake which stops the spindle almost instantly. This permits quick removal of finished pieces and setting up of blanks, and it also permits the spindle to be instantly stopped for measuring the work, etc. The spindle bearings and all the other principle bearings in the headstock are fitted with SKF self-aligning bearings.

Three spindle speeds are instantly obtainable by means of a shifting lever, and additional speeds are obtained in series of three by changing two auxiliary gears on the end of the headstock. Four auxiliary gears are furnished by means of which twelve spindle speeds are obtainable. Gears in the headstock run in a bath of oil which assures adequate lubrication. The design of the spindle has been worked out to adapt it for the use of draw-in collets. Movement of the carriage is effected by a screw located between the ways, directly under the tools; this position reduces torsional strains to a minimum. Automatic adjustable stops are provided for the carriage. A special plain rest is furnished as a regular equipment for the carriage. Rear tool-holders of the multiple-tool type for use in the performance of facing and grooving operations, etc., can also be easily mounted on the rear ways where they are entirely independent of the carriage. Cross-feed to the rear tool-holders is operated by a handwheel at the front of the bed and both the front and back tools are equipped with positive stops. A back-rest, taper attachment, draw-in attachment and collets, oil-pump, etc., can be furnished as special equipment whenever required.

The principal dimensions of this lathe are as follows: swing over bed, 9 inches; swing over plain rest, 7 inches; distance between centers, 12 inches; diameter of hole through spindle, 1⅜ inch; maximum collet capacity, 1 inch; diameter of spindle nose, 2⅛ inches; threads per inch on spindle nose, ten; size of cutting tool, 5/8 by 1⅜ inch; length of carriage on bed, 18 inches; diameter of driving pulley, 8½ inches; width of driv-

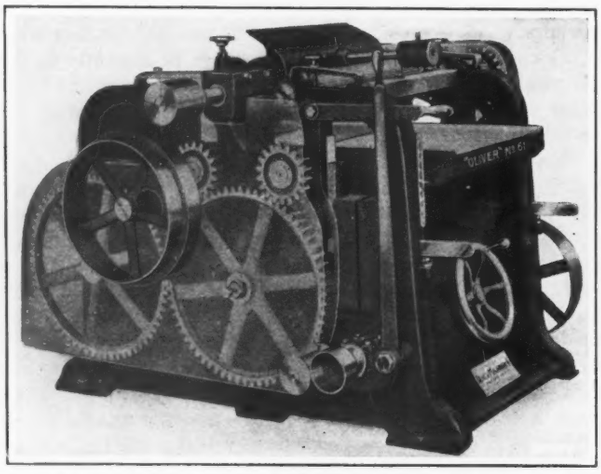


"Sundstrand" Manufacturing Lathe built by Rockford Tool Co.

ing belt, 2¾ inches; regular speed of driving pulley, 350 revolutions per minute; number of available spindle speeds, 12; number of available feed changes, 4; floor space occupied by machine, 45 by 24 inches; and weight of machine crated for shipment, 1050 pounds.

OLIVER SINGLE-CYLINDER SURFACER

The Oliver Machinery Co., 7 Coldbrook St., Grand Rapids, Mich., are now building a single-cylinder four-roll cabinet surfacer which forms the subject of the following description. This machine is adapted for handling a wide range of work in both soft and hard woods. It is suitable for use in pattern shops and factories engaged in the manufacture of furniture, pianos, organs, boats, interior finish, etc. The machine is made in two sizes with capacities for planing work up to 24 and 30 inches in width, and adjustment of the bed is provided so that it may be dropped sufficiently to plane material up to 8 inches in thickness. The available rates of feed are 14, 18, 24, and 31 feet per minute. The cylinder is made of a crucible steel forging which is belted at both ends. It carries two thin high-



Single-cylinder, Four-roll Surfacer built by Oliver Machinery Co.

speed air-hardened steel knives, which are securely clamped against hard steel chip breakers whose lips are shaped to throw off shavings and chips. The cylinder pulleys are carefully balanced and their faces are grooved spirally to prevent air pockets forming under the belts.

Self-oiling bearings support the cylinder; these bearings are of the side clamping type and readily adjustable to hold the cylinder firmly in place to assure smooth running. Power for the feed motion is transmitted through belts from the cutting cylinder, and the feed is under instant and positive control by the operator. Ample power and positive operation are assured, and there are four rates of feed which have already been given. There are four feed-rolls, one pair being located back of the cylinder to feed the material free from the knives and assist in carrying it through the machine. These rolls are made of hammered steel and suppored in self-oiling bearings. The upper "feed-in" roll is corrugated to enable it to secure a firm grip on the work. All rolls are driven by a train of heavy gearing, the teeth of which are cut to insure smooth operation of the feed mechanism.

NEW MACHINERY AND TOOLS NOTES

Friction Clutch Countershaft: Foster Machine Co., Elkhart, Ind. A line which comprises six sizes of double-friction countershafts and six sizes of triple-friction countershafts. These are of the expanding friction-ring type and Hyatt roller bearings are used on all loose pulleys.

Elevating Truck: Cowan Truck Co., 88 Canal St., Holyoke, Mass. A Type H transveyor equipped with a hydraulic lifting mechanism. This truck is intended for heavy service and is adapted for carrying loads up to 5000 pounds. Provision is made for elevating the platform 3 inches by means of a hydraulic ram which is operated by a few strokes of the handle.

Filing Machine: W. F. Davis Machine Tool Co., Inc., 85 Liberty St., New York City. This is known as the "20th Century" filing machine It is of the bench type and may be arranged for either belt drive or individual motor drive. The stroke of the machine is adjustable from 0 to 2 inches, and the table may be quickly set and locked at any desired angle.

Multiple-spindle Valve Grinding Machine: Defiance Machine Works, Defiance, Ohio. A line of machines designed for the purpose of grinding valves in internal combustion engine cylinders. These valve grinding machines are built in three different sizes with four, six, and eight spindles, respectively. Adjustment is provided to take care of different distances between valve centers.

Drinking Fountain: D. A. Ebinger Sanitary Mfg. Co., Columbus, Ohio. This is known as the "Ebco" fountain, and it is mounted in a cooler in such a way that the stream of water flows up at an angle from beneath a guard, making it impossible for anyone to place his mouth on the nozzle. This form of jet also makes it possible to fill a glass or drinking cup at the fountain.

Sanding Machine: Carter & Bucholz Co., Inc., 1234 S. State St., Syracuse, N. Y. An oscillating spindle sanding machine adapted for use by pattern-shops and wood-working plants. It is equipped throughout with New Departure ball bearings and is driven by a 1/2-horsepower enclosed ball bearing motor. The table is 20 inches in diameter and it tilts 45 degrees downward or 15 degrees upward.

Grinding Stand: Luther Grinder Mfg. Co., 285-289 S. Water St., Milwaukee, Wis. An improved No. 271 "Hummer" grinding stand, which is known as a "Model F." It is provided with a worm-gear drive instead of cast bevel gears, and ball bearings have been incorporated to insure easy operation. This grinding stand is intended to be driven by foot-pedals and is adapted for use where power is not available.

Tool-holders: Right and Left Tool-holder Co., Jasper and E. Willard Sts., Philadelphia, Pa. A tool-holder intended for using up short bits of high-grade steel. A short tool bit is held between the body of the holder and a cap which is clamped down by means of a square-headed screw. These holders are made of high-carbon steel and can be furnished in straight, right-hand offset or left-hand offset types as desired. They are made in eight different sizes.

Scrap Metal Baling Press: Galland-Henning Mfg. Co., Milwaukee, Wis. A hydraulic baling press which automatically ejects the baled sheet metal scrap so that the bundle may be carried out on a conveyor leading to the scrap pile, or into a car or charging hopper. A grooved liner plate is provided in the charging box, and guides on the plunger fit into these grooves to guard against wedging of scrap metal between the plunger head and the sides of the box.

Geared-head Lathe: Springfield Machine Tool Co., 631 Southern Ave., Springfield, Ohio. A geared-head lathe built in 14-, 16-, 18-, and 20-inch sizes and furnished with individual motor drive or belt drive. All journals except the main spindle bearing are furnished with ball bearings and speed changes are arranged in geometrical progression, any desired speed being available without having to pass through any series of speeds to reach the one which is desired.

Attachment for Brinell Test: Pittsburg Instrument & Machine Co., Pittsburg, Pa. An attachment for use in measuring the depth of impressions made in conducting the Brinell hardness test. It is claimed that the depth of impression can be measured with greater accuracy than the diameter, and with this attachment the claim is made that the depth can be determined to 0.01 millimeter. One complete turn of the needle of the dial indicator represents a depth of 1 millimeter.

Metal Product Washing Machine: Ideal Concrete Machinery Co., Cincinnati, Ohio. A machine for cleaning and rinsing metal products by the batch process. This equipment is particularly adapted for removing grease from stampings and drawn work of steel or brass. Work can be held in the drum, passing continuously through the cleaning solution until thoroughly cleaned, after which it enters the rinsing drum and then passes on to draining and drying screens.

Bench Lathe: DeMant Tool & Machine Co., 79 E. 130th St., New York City. A precision bench lathe furnished with headstock and tailstock spindles which are hardened and ground, and supported in bearings furnished with means of compensating for wear. A compound rest and a three-speed countershaft form part of the regular equipment of this machine, and the compound rest is designed with large graduated dials which facilitate making accurate settings.

Stock Support: A. F. Way Co., Inc., Hartford, Conn. An adjustable stock support which is intended for use in connection with hacksaw machines, screw machines, band and circular sawing machines, bolt cutters, threading machines, pipe machines, etc. It will be found convenient wherever long bar stock or tubing has to be handled in a machine. The support is furnished with a base of ample size to prevent it from being turned over, and the height of the column may be quickly adjusted.

Planing Machine: Liberty Machine Tool Co., Hamilton, Ohio. A 36-inch planing machine designed to meet the requirements of modern shop practice, and equipped with all necessary safety appliances and conveniences to safeguard the operator and provide efficient operation of the machine. A patented feed mechanism is furnished which is independently adjustable on either the cross-rail or the side head, so that the operator may change the rate of feed while the machine is running.

Chord Plates: R. W. Beckman Co., 920 Hume-Mansur Bldg., Indianapolis, Ind. A device particularly intended for use in grinding tapers, although it may be used for other classes of work. This chord plate is made in 3- and 6-inch sizes, and in two styles, namely, horizontal and vertical. It consists of a baseplate carrying a revolving upper plate upon which the work is mounted by any suitable means. The angular setting is determined by measuring the chord of the arc by means of a micrometer used over two measuring points.

Proportional Mixer: Eclipse Fuel Engineering Co., Rockford, Ill. A device known as the "McKee" proportional mixer which may be used in connection with practically any furnace installation where gas is used as a fuel. This device provides for delivering gas and air mixed in any predetermined proportions, and is claimed to save fuel and also provide for obtaining any desired type of flame; that is to say, a reducing, oxidizing, or neutral flame. This device is made in three sizes with outlets 1½, 2 and 3 inches in diameter, with gas capacities per hour of 600, 1000 and 2000 cubic feet.

Engine Lathe: Sidney Tool Co., Sidney, Ohio. A heavy-duty engine lathe built in 30- and 36-inch sizes. The vees on the bed are cast with a 25 per cent steel mixture which affords a close grained metal with high resistance against wear. The spindle is made of 50-point carbon steel and is carried in liberally proportioned bearings which are lined with phosphor-bronze. The lead-screw is 1 11/16 inch in diameter and is made of 40-point carbon steel. The machine is said to be especially adapted for the extremely heavy-duty service found in car shops, rolling mills, shipbuilding yards, etc.

Shell Calking Hammer and Rivet Header: High-Speed Hammer Co., Inc., Rochester, N. Y. A hammer especially adapted for calking or peening the gas check plugs on 155-millimeter shells. The shell is placed in the machine and a burring tool is applied in such a way that one or two revolutions of this tool by the handles, when under slight pressure, will remove any burrs from the dovetail base. The plug is then inserted and a lead gasket is dropped into position, after which the hammer peens it into place. The rivet heading machine is suitable for upsetting the heads of copper rivets used in harness, etc.

Drill Head and Gear Chuck: Garrison Machine Works, Dayton, Ohio. This company is now manufacturing a line of multiple-spindle drilling heads for use on a single-spindle drilling machine to provide for simultaneously drilling a number of holes. The line includes a variety of different heads to meet the requirements of various classes of work. The gear chuck is so designed that provision is made for holding a variety of different forms of work which have gear teeth cut on them. It is claimed that this chuck will hold gears with sufficient accuracy to provide for machining holes concentric with the pitch circle within 0.001 inch.

Boring, Milling, Drilling, and Tapping Machine: Defiance Machine Works, Defiance, Ohio. A No. 6 horizontal machine for the performance of these four operations, on which the maximum distance from the faceplate to the back-rest is seven feet, and the maximum distance from the top of the platen to the center of the spindle is 37 inches. A spindle 4½ inches in diameter provides ample driving power, and the table is 36 inches square with a maximum cross travel of 64 inches. Ten changes of speed are available, ranging from 7½ to 157 R.P.M., and there are twelve available rates of feed changes to all actuating screws covering a range from 0.004 to 0.500 inch per revolution.

* * *

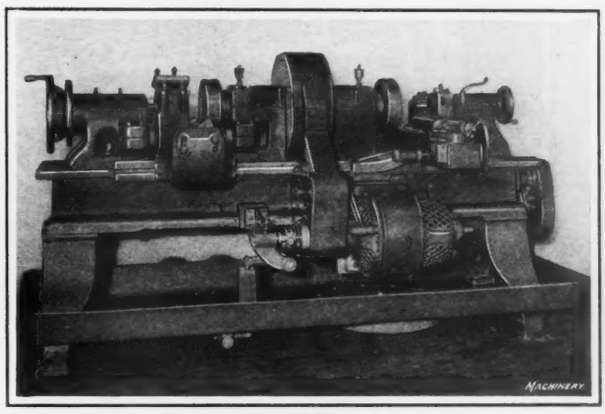
PERMANENT EXHIBITION OF MACHINERY IN NEW YORK CITY

A permanent display and salesroom for machinery and mechanical appliances is being planned in New York City, to be operated by what is known as the Merchants and Manufacturers Exchange of New York, the display and salesroom being located in the Grand Central Palace, Lexington Ave. and 46th St. The machinery exhibition will occupy an entire floor of the building, having an area of 50,000 square feet of floor space. For the convenience of the buyer, a general information bureau and reading room will also be maintained where important trade and technical journals and catalogues will be kept on file. All communications should be addressed to the Machinery Sales Department, Grand Central Palace, New York City.

CENTER-DRIVE LATHE

The center-drive lathe shown in the accompanying illustration was originally designed for the Ford Motor Co. for turning both ends of an automobile driving shaft simultaneously. The work is passed through an opening in the left-hand tailstock, which is brought into position by indexing the barrel of the tailstock 180 degrees, at which position the work passes directly into the spindle in the headstock. After the work has been passed through the tailstock, the tailstock barrel is again indexed 180 degrees, to bring the center into position. The work is then mounted on the centers, after which the chucks (which are of the floating type) are bound or clamped to the work. The chucks are then secured to the driving plate. When the machine is started, the two carriages feed toward the center headstock, thereby turning the various diameters at each end of the work, as well as the outer portion.

While this turning is in process, the back-arm tools are simultaneously squaring down the shoulders which are necessary on the shaft. The action of the carriage transmits radial motion to the back-arm tool-block. This motion is obtained through the medium of a cam which is secured to the bracket



Center-drive Lathe

fastened to the rear of the carriage. An extension arm with a roller, which comes in contact with the cam, is secured to the back-arm bar. The cam, in its longitudinal travel along the bed, must necessarily transmit a rocking or radial action to the back-arm block and tools, thereby performing the squaring operation. This machine is driven by a five-horsepower Westinghouse Type SK motor, which runs at 1100 revolutions per minute, and the stopping and starting of the spindle are effected through the medium of an internal expanding clutch provided on an extension of the motor shaft. The drive from the motor to the head spindle is through a set of sprockets and a Morse silent chain, and an idler pulley is provided to take up the slack. These machines were designed and manufactured by the Reed-Prentice Co., Worcester, Mass.

* * *

APRIL MEETING OF AMERICAN SOCIETY OF MECHANICAL ENGINEERS

The April meeting of the New York Section of the American Society of Mechanical Engineers, held in the Engineering Societies Building, 29 W. 39th St., New York City, Tuesday, April 9, was attended by about four hundred members. The feature of the meeting was to bring together the members of the New York Section and the Metropolitan Student Branches of the society. Many addresses were made by prominent speakers relating to the important features of how engineers are helping to win the war. Sessions were held both in the afternoon and in the evening. At the latter session, Ira N. Hollis, president of the Worcester Polytechnic Institute and past president of the society, gave an inspiring address, and B. F. Hart, Jr., lieutenant in the United States Naval Reserve Force, dealt with the accomplishments of the United States Navy in the war. The event of the evening was an interesting lecture and motion picture on the war in the air, by G. Douglas Wardrop, editor of *Aerial Age*.

"Built to Stand the Steady Drive for the Busy Shop"

No. 13

A Time-tried Profit-proved INVESTMENT

for the shop using Spur and Bevel Gears in quantities too small to warrant the installation of both a spur gear cutting and a bevel gear cutting machine.

This Machine Cuts with Speed and Precision—

Both Spur and Bevel Gears also Sprockets and Clutches

Indexing is rapid and independent of speed and feed of cutter. Rigid design allows rapid, heavy cuts to be taken without loss of accuracy.

Constant speed drive with high belt speed and large belt contact insures ample power to pull heavy cuts.

Their handiness in operation and their adaptability to a wide range of work instantly appeals to every gear man who has faced the problem of handling the variety of work that can be cut on these machines.

Let us tell you all about them Send for literature

BROWN & SHARPE

SPUR and BEVEL GEAR CUTTING MACHINE

CAPACITY:

Spur and bevel gears to 18 inch diameter, 4 inch face. Cast iron, 4 diametral pitch. Steel, 5 diametral pitch.

Specify B&S Machines

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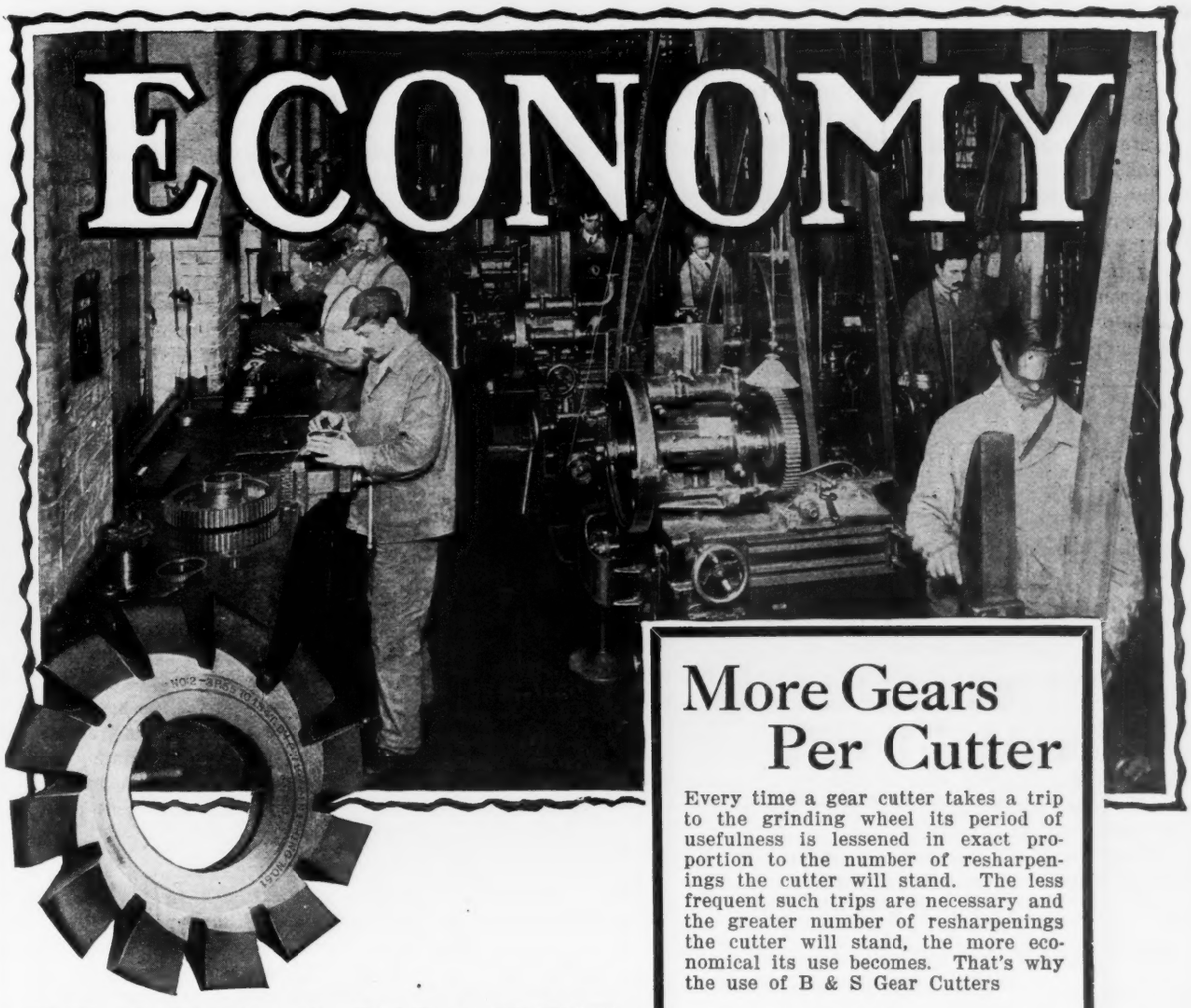
ECONOMY



More Gears Per Cutter

Every time a gear cutter takes a trip to the grinding wheel its period of usefulness is lessened in exact proportion to the number of resharpenings the cutter will stand. The less frequent such trips are necessary and the greater number of resharpenings the cutter will stand, the more economical its use becomes. That's why the use of B & S Gear Cutters

In Your Gear Cutting Department

is a big help toward the economical production of high-grade gears. They stand up under heavy cuts for long periods between resharpenings owing to careful selection of materials and improved methods of heat treatment. They will stand many trips to the grinding wheel because the way they are cut and relieved allows the teeth to be ground almost to the back edge.

Send for Catalog 27

It's a reliable guide to a reliable cutter service

BROWN & SHARPE
INVOLUTE
GEAR CUTTERS

This cut shows condition of cutter after extensive service. Its record shows that it has cut through thousands of feet of stock and is still capable of further service—its form unchanged—its accuracy unimpaired.

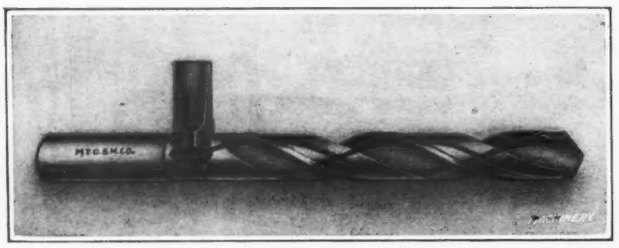
Providence, R. I., U. S. A.

REPRESENTATIVES: **BALTIMORE, MD.**, Carey Machinery & Supply Co. **CINCINNATI, O., INDIANAPOLIS, IND.**, The E. A. Kinsey Co. **SAN FRANCISCO, CAL.**, Pacific Tool & Supply Co. **CLEVELAND, O., DETROIT, MICH.**, Strong, Carlisle & Hammond Co. **ST. LOUIS, MO.**, Colcord-Wright Machinery & Supply Co. **SEATTLE, WASH.**, Perine Machinery Co. **PORTLAND, ORE.**, Portland Machinery Co.

Specify B&S Cutters

HISTORICAL NOTE ON OIL-DRILL DEVELOPMENT

At the World's Fair in Chicago, in 1893, the Morse Twist Drill & Machine Co., of New Bedford, Mass., exhibited tools in which provision was made for conveying lubricant directly to the point of a drill or cutting tool. The drills exhibited at that time were duplicates of some made during the two previous years under patents granted to the T. & B. Tool Co., and subsequently acquired by the Morse Twist Drill & Machine Co. Various devices have been used for conveying lubricant to the cutting point of a twist drill or other tool, the early method being to insert a tube, although this practice has subsequently been replaced by cutting holes through the solid metal. All Morse oil drills 2½ inches in diameter and smaller have holes drilled through the solid metal, while drills larger



Morse Oil Twist Drill

than 2½ inches in diameter have oil channels milled in them, which are covered in order to make closed passages through which the lubricant is delivered. In the case of taper shank drills, the oil-hole may extend right through to the end of the shank, it may connect with a cross-hole drilled midway between the large and small ends of the shank or connection may be similar to that shown in the accompanying illustration. Straight-shank oil drills are also made with the oil-hole extending through to the end of the shank.

* * *

GEAR MANUFACTURERS' CONVENTION

The second annual convention of the American Gear Manufacturers' Association was held at White Sulphur Springs, W. Va., April 18 to 20. Several papers were presented, two of which are abstracted elsewhere in this number. The papers of particular mechanical interest were "Gear Standardization," by B. F. Waterman, of the Brown & Sharpe Mfg. Co., Providence, R. I.; "Heat-treatment of Gears," by C. R. Poole, of the Frost Gear & Forge Co., Jackson, Mich.; and "Hobs and Hobbing Machines," by F. G. Hoffman and John Edgar, of the Barber-Colman Co., Rockford, Ill. The following officers were elected: President, F. W. Sinram, Cleveland, Ohio; vice-president, H. E. Eberhardt, Newark, N. J.; secretary and treasurer, Frank D. Hamlin, Philadelphia, Pa. The executive committee consists of the three officers mentioned, elected for three years, and, in addition, Frank Burgess, Boston, Mass., George L. Markland, Jr., Philadelphia, Pa., Milton Rupert, Pittsburg, Pa., elected for two years; and William Ganschow, Chicago, Ill., E. J. Frost, Jackson, Mich., and H. W. Chapin, Syracuse, N. Y., elected for one year. About fifty members were present.

* * *

NATIONAL METAL TRADES' ASSOCIATION CONVENTION

The twentieth annual convention of the National Metal Trades' Association, held at the Hotel Astor, New York City, April 24 and 25, formed the occasion for the presentation of many addresses and papers, national in their scope and value. Among others, that by W. A. Viall, of the Brown & Sharpe Mfg. Co., Providence, R. I., on "The Employment of Women in an Industry" was of great interest and value at this time when so many manufacturers are considering the solution of this problem. F. A. Halsey, commissioner of the American Institute of Weights and Measures, presented a resume of the work of the institute, and several addresses of a patriotic character, bearing upon the relation of the industries to the national welfare, were also presented.

HELPING UNCLE SAM

The branch office of the Inspection Division, Ordnance Department, 600 W. Jackson Blvd., Chicago, Ill., has immediate need for 250 to 300 inspectors. At present the positions of inspector of field artillery ammunition and inspector of carriage division are open, which pay a salary of $3.50 to $5 for an eight-hour day. These positions are in the vicinity of Chicago. It is anticipated that many more examinations will be opened up immediately. Women applicants between the ages of twenty-one and fifty and men between the ages of thirty-one and fifty will be considered. Applicants are especially needed who have had artillery ammunition, carriage, motor, small arms, or small arms ammunition experience. There is immediate need for the services of these inspectors and applicants are expected to report to Mr. Becker, 600 W. Jackson Blvd., Chicago, Ill., for interview and application blank.

The Bureau of Mines Experiment Station, at Washington, D. C., requires the services of trained men of the following qualifications in the engineering trades: Draftsmen, electrical engineers, instrument makers, machinists, plumbers, steamfitters, as well as chemists and chemical engineers. Men whose training fits them for any of these occupations should address the Bureau of Mines, American University Experiment Station, Washington, D. C. Blank forms will then be sent to the applicant for filling in information relating to his experience and qualifications. These blanks will be placed on file and the applicant will be notified as soon as his services are required. Those who have registered for the draft but have not yet been ordered to camp may enter immediately into this service, while those who are not in the draft, but feel that they wish to serve their country in the present crisis, may either enlist or serve as civilians.

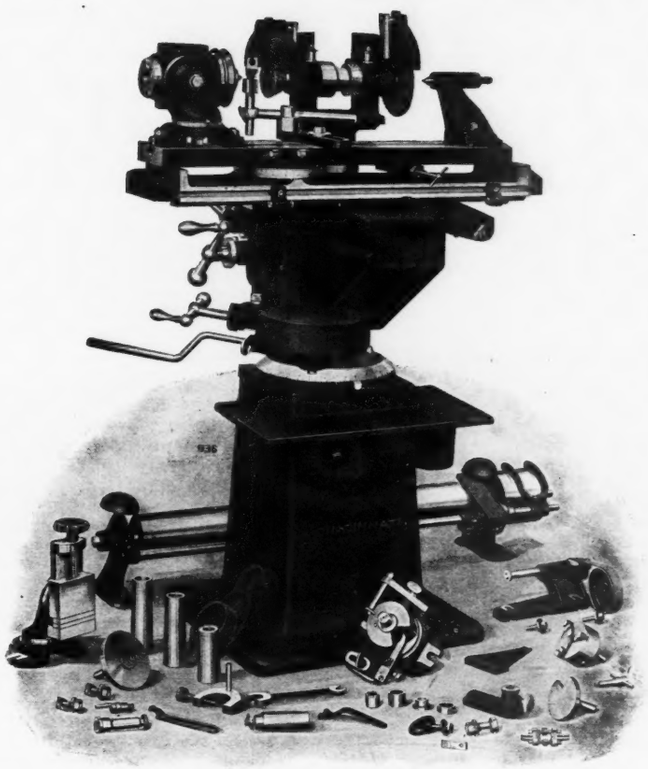
Most of the younger technical men in the Government's Reclamation Service, the Bureau of Standards, and the Geological Survey have been detailed for special war service either at home or abroad, and the draft has cut off from these branches their usual supply of new men; hence, the personnel of these departments is so depleted that it is almost impossible for them to do their regular work. In this emergency, therefore, the Government calls upon technical students of the country. From May 1 to October 1, there is much work in these departments that can be performed by undergraduates of technical training. Those particularly desired are young men of good physique who are below the draft age. The requirements for work in the Bureau of Standards are not less than one year of college work in physics and mathematics; in addition, special mechanical and testing skill is desirable. For the Reclamation Service, not less than one year of college work in civil engineering and surveying is required, and for the Geological Survey, not less than one year of college work in civil engineering. Men with drafting experience are particularly desired. The qualifications mentioned are the minimum requirements; additional qualifications will lead to better paid positions. Further information may be obtained by writing to the following department heads: Dr. W. S. Stratton, director of the Bureau of Standards, Washington, D. C.; Dr. George Otis Smith, director of the Geological Survey, Department of the Interior, Washington, D. C.; or A. P. Davis, director of the Reclamation Service, 8th and E Sts., Washington, D. C.

* * *

CORRECTION

In the New Machinery and Tools note on page 759, in the April number of MACHINERY, the statement was made in describing the reclaiming tang placed on the market by the Mailometer Co., Detroit, Mich., that the tool to be reclaimed can be ground to fit the shoulder provided on the new tang of which the device consists. The statement should have been as follows: When the tang breaks, it is hacksawed off to fit the driving shoulder on the new tang, the special advantage being that the hacksaw is the only tool required by means of which the drill is fitted for use with the tang.

CLEARANCE



The No. 1½ Cincinnati Universal Cutter and Tool Grinder

Patent Rights Fully Reserved

You wouldn't think of using lathe tools with the wrong clearance. On milling cutters correct clearance is even more important.

Incorrect cutter clearance will reduce the output of your milling machines as much as twenty per cent.

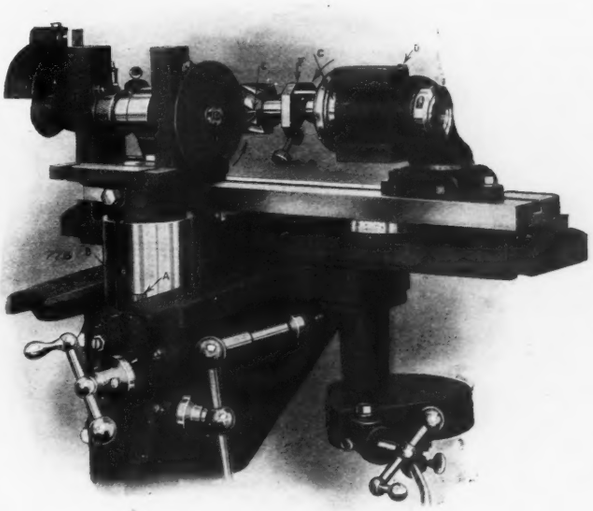
Clearance depends upon certain mathematical relations between the cutter and the grinding wheel.

To obtain these on the ordinary grinder requires several measurements and reference to diagrams, tables or charts.

The average operator doesn't understand these and after a couple of trials grinds until the clearance looks right—and your milling department suffers.

Compare the Cincinnati method. After a simple preliminary setting the swivel head is revolved the desired amount, the clearance angle being read direct from the dial—the cutters are ground with the correct clearance—and your milling department profits.

This is only one of our *exclusive features.*



Method of setting for clearance

Catalog tells them all

Cincinnati Milling Machine Company

CINCINNATI **OHIO, U. S. A.**

OBITUARIES

Adolphe Janssens, formerly one of the largest dealers in machine tools in Paris, France, died on March 8 last, at the age of sixty-five. Mr. Janssens retired from business some years ago.

Colonel George Pope, president of the National Association of Manufacturers and formerly prominently connected with the Pope Mfg. Co., Hartford, Conn., died April 19, at his home in Hartford, aged seventy-four years. Colonel Pope was a national figure in the automobile industry and was, at one time, chairman of the Automobile Board of Trade. He was born in Boston, Mass., January 9, 1844, and was a veteran of the Civil War.

Richard Ward Baker, superintendent of Outside Construction with the Watson-Stillman Co., New York City, died March 24 from apoplexy at his home in Roselle, N. J., aged sixty-eight years. Mr. Baker spent his entire business life in the service of the Watson-Stillman Co., having entered the company's employ at the age of fourteen, finally becoming superintendent, which position he held for many years. Upon the completion of fifty years' service in 1914, the Board of Directors presented Mr. Baker with a check and a copy of a resolution setting forth the company's appreciation. Mr. Baker is survived by his wife and one son.

Rufus Franklin Emery, secretary and treasurer of the Westinghouse Airbrake Co., Pittsburg, Pa., died April 11 from heart failure, aged forty-eight years. Mr. Emery was born near Boston, and, coming to the Pittsburg district in 1891, became affiliated with the Westinghouse interests, in whose upbuilding he played an important part. He was also assistant secretary of the American Brake Co., assistant secretary and a director of the National Brake & Electric Co., a director of the Vulcan Crucible Steel Co., secretary and treasurer and a director of the Westinghouse Friction Draft Gear Co. and treasurer and a director of the Westinghouse Traction Brake Co. He was a public-spirited citizen and took an active interest in various religious, social, civic, and patriotic movements.

PERSONALS

D. B. Clark, formerly superintendent of the Shell Department of the American Brake Shoe & Foundry Co., Erie, Pa., is now general superintendent of the Watervliet Arsenal, Watervliet, N. Y.

D. F. Noble, for the past four years connected with the Sales Department of the E. L. Essley Machinery Co., Chicago, Ill., has resigned and is now in the Sales Department of the Marshall & Huschart Machinery Co., Chicago, Ill.

A. H. Willey, for some time connected with Hermann Boker & Co., has joined the selling force of the Reliance Steel & Tool Co., 30 Church St., New York City, and will have charge of the Pennsylvania territory, with headquarters in Philadelphia.

Laura G. Edwards, for more than ten years connected with the National Tube Co., Pittsburg, Pa., writing advertising and other copy for publication, is now in the Publicity Department of the A. M. Byers Co., of Pittsburg, manufacturers of wrought-iron pipe.

F. S. Cole, formerly with the Imperial Belting Co., Chicago, Ill., is now with the Industrial Bearings Division of the Hyatt Roller Bearing Co., Metropolitan Tower, New York City. Mr. Cole will specialize on the sale of Hyatt roller bearings for lineshafting.

August Mertes, for some years superintendent of the Pittsburg Machine Tool Works, Pittsburg, Pa., has resigned to take a similar position with the Bradney Machine Co. of Middletown, N. Y., builders of locomotive cranes, elevating machinery, and machine shop tools.

Fred B. Crosby has resigned his position in the Power and Mining Engineering Department of the General Electric Co., Schenectady, N. Y., to become electrical engineer with the Morgan Construction Co., Worcester, Mass. Mr. Crosby has specialized in electrical equipment for steel works.

A. E. Ward, formerly with the Prest-O-Lite Co. and for many years associated with the compressed gas industries, has been appointed sales manager of the International Oxygen Co., 115 Broadway, New York City. Through his long experience Mr. Ward has gained recognition as an expert in the industrial applications of oxygen, hydrogen, and acetylene.

Vilhelm Christensen, of the firm of V. Lowener, with offices in New York, Copenhagen, Stockholm, Christiania, and Moscow, sailed for Copenhagen in the early part of April. Mr. Christensen has been studying the use of modern small tools and appliances for several years in this country. He will join the Tool Department of the main office of V. Lowener in Copenhagen in order to stimulate the use of American tools in the Scandinavian countries.

C. R. Dooley, manager of the Educational Department of the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., has been granted a leave of absence to accept an appointment by the Government as director of the Vocational Educational Project for Army Needs, now being developed by the War Department Committee on Educational and Special Training. He will be located in the War Department at Washington, D. C. During Mr. Dooley's absence, his duties will be assumed by C. S. Coler, who has been appointed acting manager of the Educational Department.

Colonel Henry P. Bope has resigned his position as vice-president and general manager of sales with the Carnegie Steel Co., Pittsburg, Pa., to devote his time to private interests. Colonel Bope became connected with Carnegie Bros. & Co. in 1879, and has remained continuously in the sales work of that company and its successors up to the present time. He has been succeeded by William G. Clyde, whose connection with the U. S. Steel Corporation and its subsidiaries dates from 1894, when he became superintendent of the plate mills of the Illinois Steel Co. at South Chicago. Charles L. Wood, who has been assistant to Mr. Clyde, has been made assistant general manager of sales in charge of the Bureau of Bars and Hoops.

Charles Philip Coleman has been elected president of the Worthington Pump & Machinery Corporation, 115 Broadway, New York City. Mr. Coleman has been vice-president of the corporation since May, 1916, and prior to that date was the receiver of the International Steam Pump Co. and associate companies, which have now been reorganized into the present corporation. Mr. Coleman is a graduate in mechanical engineering of the Lehigh University and was afterward employed by the Lehigh Valley Railroad in various positions as car agent, chemist, engineer of tests, assistant to the general superintendent, general storekeeper, and general purchasing agent, until 1903. Later he became secretary and treasurer of the Singer Sewing Machine Co., and president of the Saurer Motor Co. and of the International Motor Co. He came to the International Steam Pump Co. in 1913 as vice-president.

COMING EVENTS

May 15-17—Joint convention of the National Supply and Machinery Dealers' Association, Southern Supply and Machinery Dealers' Association and the American Supply and Machinery Manufacturers' Association at Hotel Hollenden, Cleveland, Ohio. Secretary of the American Supply and Machinery Manufacturers' Association, F. D. Mitchell, Woolworth Bldg., New York City.

May 16-17—Spring meeting of the National Machine Tool Builders' Association at the Marlborough-Blenheim Hotel, Atlantic City, N. J. Charles E. Hildreth, care of Whitcomb Blaisdell Machine Tool Co., Worcester, Mass., general manager.

May 20-22—Twenty-third annual convention of the National Association of Manufacturers in New York City. Secretary, George S. Boudinot, 30 Church St., New York City.

May 30—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

June 20-22—Fifth annual convention of the American Drop Forge Association held at the Iroquois Hotel, Buffalo, N. Y. E. B. Horne, "The American Drop Forger," 108 Smithfield St., Pittsburg, Pa., secretary.

October 7-12—Joint convention of the American Foundrymen's Association and the American Institute of Metals in Milwaukee, Wis. Concurrent with these meetings there will be an exhibition of foundry equipment, machine tools, and accessories.

SOCIETIES, SCHOOLS AND COLLEGES

Columbia University, Morningside Heights, New York City. Bulletin of the day and evening courses for the 1918 summer session, beginning June 5 and ending August 16.

Rochester Athenaeum and Mechanics Institute, Rochester, N. Y. Bulletin of the Departments of Mechanics, Electricity, and Chemistry of the School of Industrial Arts, for 1918-1919.

NEW BOOKS AND PAMPHLETS

Comparative Tests of Six Sizes of Illinois Coal on a Mikado Locomotive. By Edward C. Schmidt, John M. Snodgrass, and Otto S. Beyer, Jr. 101 pages, 6 by 9 inches. Published by the Engineering Experiment Station of the University of Illinois, Urbana, Ill., as Bulletin No. 101.

Stabilized-Platform Weighing Scale of Novel Design. By Frederick J. Schlink, associate physicist of the Bureau of Standards. 28 pages, 7 by 10 inches; illustrated. Published by the Department of Commerce, Washington, D. C., as Bulletin No. 106 of the Bureau of Standards. Price, 5 cents.

Essentials of Drafting. By Carl L. Svensen. 184 pages, 6 by 9 inches; 450 illustrations. Published by D. Van Nostrand Co., 25 Park Place, New York City. Price, $1.50.

In his capacity of assistant professor of engineering drawing at the Ohio State University, the author of this book has had an excellent opportunity to adapt it to instruction purposes in engineering and trade schools. The book is specifically intended for the evening technical school, and has been prepared with a view to making it a part of the technical course at the Ohio Technical Drawing School. One of the main features of the work is the great number of examples of drawings shown and the practical nature of these examples, the majority of the sketches being from various kinds of machine parts. The book is divided into twenty chapters, the last of which contains questions and problems for the students, while each of the other nineteen takes up some particular phase of mechanical drawing. The chapters are headed as follows: Drawing Instruments and Materials; Lettering; Constructions; Projections; Materials and Stresses; Screw Threads; Bolts and Screws; Riveting; Working Drawings; Sections; Dimensioning; Machine Construction; Sketching; Estimation of Weights; Piping; Intersections; Developments; Picture Drawing; Shade Line Drawings; Drawing Questions, Problems, and Studies.

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BORING, DRILLING AND

MILLING MACHINE

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ALWAYS BETTER

LUCAS MACHINE TOOL CO., NOW AND ALWAYS OF CLEVELAND, O., U.S.A.

NEW CATALOGUES AND CIRCULARS

H. P. Maughlin Co., Columbus, Ohio. Circular giving price lists of numbering tacks and pattern letters and figures.

Genesee Mfg. Co., Rochester, N. Y. Circular descriptive of the Genesee facing tool for counterboring, facing, and forming.

Link-Belt Co., Chicago, Ill. Book 358, containing information on Link-Belt roller chain and giving tables of dimensions, strength, etc.

Buckeye Twist Drill Co., Alliance, Ohio. Catalogue giving tables of dimensions and prices of twist drills, sockets, shanks, reamers, taps, etc.

Kales Stamping Co., 441 Lafayette Blvd., Detroit, Mich. List of sizes of special steel, brass, lead, and fiber washers in stock ready for immediate shipment.

Smith-Serrell Co., Inc., 144 Cedar St., New York City. Catalogue of Francke flexible coupling installations and revised list prices of Francke flexible couplings.

West Haven Mfg. Co., 30 Church St., New York City. Catalogue 15 of hacksaws, band saws, nail sets, center-punches, tap and reamer wrenches, jackscrews, etc.

Taylor Welder Co., Warren, Ohio. Catalogue of the Taylor process of electric welding, illustrated with diagrams and halftones, showing Taylor electric spot-welding machines.

Driver-Harris Co., Harrison, N. J. Circular of "Nichrome" wire mesh containers for pickling, hardening, and heat-treating, containing testimonial letters from a number of users.

Electric Controller & Mfg. Co., Cleveland, Ohio. Net price sheets for electric controllers, brakes, push-buttons, starters, rheostats, switches, and other electric apparatus made by the company.

Greenfield Tap & Die Corporation, Greenfield, Mass. Catalogue 38 of pipe tools, showing the complete line of pipe tools manufactured by this company, and giving tables of dimensions and prices.

DeVilbiss Mfg. Co., Toledo, Ohio. Catalogue illustrating and describing finishing room equipment, including "Aerons," exhausting equipment, air-lift turntables and wheel jacks, air compressors, etc.

Norma Co. of America, 1790 Broadway, New York City. Circular of Norma ball bearings for fractional horsepower motors, which require anti-friction bearings that will reduce friction losses to a minimum.

Cleveland Milling Machine Co., Cleveland, Ohio. Stock list of plain, side, and angular milling cutters, end-mills, T-slotting cutters, hollow-mills, slitting saws, bevel gear-cutters, involute gear-cutters, etc.

Fitchburg Machine Works, Fitchburg, Mass. Catalogue of the 8-inch "Lo-swing" lathe illustrating this size machine, its parts and attachments, and showing the set-up for turning various types of work.

Landau Machine & Drill Press Co., Inc., 368 Broome St., New York City. Circular illustrating and describing the Landau sensitive drilling machine, equipped with a multiple drilling head which can also be used for tapping.

Westinghouse Electric & Mfg. Co., East Pittsburg, Pa. Circular 7174, dealing with electrical equipment for cement mills and giving the advantages of motor drive for this work, together with the characteristics of motors for this service.

Winfield Electric Welding Machine Co., Warren, Ohio. Catalogue entitled "Electric Welding by the Winfield Way," illustrating and describing Winfield spot-welding machines and giving data on the design, comparative cost of the process, etc.

Transmission Ball Bearing Co., Inc., Military Road, Buffalo, N. Y. Pamphlet entitled "It Takes a Load to Show the Friction," giving dimensions of Transmission ball bearings, which it is claimed effect a saving of 15 per cent of the total power consumption.

Aluminum Castings Co., 6205 Carnegie Ave., Cleveland, Ohio. Circular entitled "Small Parts and Big Points," telling of the care with which "Lynux" bronzes are made by bushing and bearing specialists to insure the production of long-wearing, high-speed, heavy-duty bearing bronzes.

Aluminum Castings Co., Cleveland, Ohio, are issuing a circular containing a letter which they term "A Printed Salesman." The letter gives information concerning "Lynux" bronze, and is intended to take the place of a part of the regular traveling force, as about 50 per cent has been lost because of the war.

Nielsen-Barton Chuck Co., 106 S. Jefferson St., Chicago, Ill. Catalogue of the Eclipse roller-bearing drill chuck, giving a concise description of the chuck, together with illustrations showing its simplicity and the convenience of its operation. The company also makes ground arbors for all kinds of drill chucks.

Driver-Harris Co., Harrison, N. J. Circular of 99 per cent pure nickel sheet, outlining the characteristics and advantages, and giving a list of products in which nickel sheet is now being used to advantage. A table of the physical properties of Grade A cold-rolled sheet nickel for drawing, stamping, and spinning is included.

Fitchburg Machine Works, Fitchburg, Mass. Catalogue of the "Lo-swing" 8½-inch lathe, containing illustrations of the machine and its various parts and attachments. A number of line drawings show different types of work set up on the "Lo-swing" lathe, and directions are included for setting up the machine.

Powell Machine Co., 243 Stafford St., Worcester, Mass. Circulars descriptive of 24- by 24-inch "Hy-speed-cut" planers; 30- by 30-inch "Hy-speed-cut" planer; 36- by 30-inch "Hy-speed-cut" planer; 36- by 36-inch "Hy-speed-cut" planers; 24- by 24-inch standard planer; 30- by 30-inch standard planer; 36- by 36-inch standard planer.

Mossberg Wrench Co., 25 Charles St., Providence, R. I. Circular descriptive of "Sim-pull" countershafts and "Sim-plex" belt shifters of the "pull-auto-lock" type. The "Sim-pull" belt shifters are made in three sizes for 1½-, 2- and 2½-inch belts, and the "Sim-plex" belt shifters are made in three sizes for 3-, 3½-, and 4-inch belts.

E F. Houghton & Co., Philadelphia, Pa. A treatise on the handling of steel, entitled "Steel and Its Treatment," dealing with the composition of steel, its hardening, tempering, and annealing. The subject is presented in regular book form, with a complete index, and covers 165 pages, 5½ by 8 inches, substantially bound in cloth binding.

J. C. Glenzer Co., 3 Fourteenth St., Detroit, Mich. Circular illustrating and describing the "Utility" interchangeable counterbore and spot-facer, the advantage of which is that the pilot cannot be twisted off. The circular contains dimensions of the cutters and pilots, the number of Morse taper with which the counterbores are provided, and price list.

Gisholt Machine Co., Madison, Wis. Circular entitled "How to Save Money on High-speed Steel," describing Gisholt tool-holders by means of which it is possible to utilize high-speed steel tools that have been worn too short to be used without holders. These tool-holders are especially designed for use in turret lathes and engine lathes equipped with turret toolposts.

Cooper-Hewitt Electric Co., Eighth and Grand Sts., Hoboken, N. J. Pamphlet entitled "Lighting for Production and Safety," by William A. D. Evans, comprising the study and selection of a system of illumination with a view to ultimate efficiency of the plant. The halftone illustrations in the book are made from photographs taken under Cooper-Hewitt lamps.

Oliver Machinery Co., 7 Coldbrook St., Grand Rapids, Mich. Circular illustrating and describing the Oliver No. 15-R combination band resaw and scroll saw with 38-inch wheel. Circular of Oliver No. 61 single-cylinder, four-roll, double-belted cabinet surfacer with capacity up to 24 and 30 inches in width and 8 inches in thickness. Circular of Oliver No. 463 high-speed double shaper with a 60- by 36-inch table.

TRADE NOTES

Hyatt Roller Bearing Co. announce that their Industrial Bearings Division is now located in the Metropolitan Tower, New York City.

Oesterlein Machine Co., Cincinnati, Ohio, manufacturers of Ohio milling machines and grinders, are now located in their new plant at 3301 Colerain Ave.

Lyon Metallic Mfg. Co., Aurora, Ill., manufacturers of all-steel equipment, including bins, shelving, lockers, etc., are erecting a large addition to their plant.

Bullard Machine Tool Co., Bridgeport. Conn., have made a 100 per cent record on the Liberty Loan, every one of their employes, numbering over 1200, having subscribed.

Diamond Chain & Mfg. Co., Indianapolis, Ind., manufacturers of chain for machine tools, are now located in their new building, which is considered one of the finest factories in Indianapolis.

Chicago Recording Scale Co., Waukegan, Ill., have opened a new department for the manufacture of dies, tools, jigs, fixtures, stampings, screw machine work, and contract work in general.

Hendey Machine Co., Torrington, Conn., have opened a branch office at 521 Chamber of Commerce Bldg., Rochester, N. Y., for the purpose of covering the northern and western parts of the state direct.

Diamant Tool & Mfg. Co., 164 Emmett St., Newark, N. J., are continuing the tool and manufacturing business of Sidney Diamant, who was formerly an owner of the DeMant Tool & Machine Co. of New York City.

Westinghouse Electric Products Co., Mansfield, Ohio, will manufacture the heating appliances previously made by the Copeman Electric Stove Co. The general manager of the company is W. K. Dunlap, who is assistant to the vice-president of the Westinghouse Electric & Mfg. Co.

Reliance Die & Stamping Co., 515 N. LaSalle St., Chicago, Ill., makers of dies, tools, gages, fixtures, and special machinery, as well as manufacturers of stampings, have enlarged their plant by adding to it a five-story building. This addition will practically double the floor space and capacity.

Rockford Tool Co., Rockford, Ill., manufacturers of lathes, have acquired the patent rights and plant of the Sundstrand Mfg. Co., who have been building a small 9-inch manufacturing lathe for some time. The Rockford Tool Co. will continue the manufacture of this lathe, in addition to their regular line.

J. R. Stone Tool & Supply Co., Detroit, Mich., dealers in machinery, tools, and machine tool accessories, moved to their new quarters at 997 Woodward Ave., May 1, where they carry a stock of new and second-hand machinery and tools of all kinds to meet the needs of the metal-working industries.

Victor R. Browning & Co., College Point, N. Y., manufacturers of hoisting and conveying machinery, are now making 5-inch naval gun mounts for the U. S. Navy Yard, and would like to obtain catalogues from manufacturers of the various parts that enter into the production of gun mounts and of factory equipment.

E. J. Flather Mfg. Co., Nashua, N. H., at a recent meeting of the stockholders, changed the name of the corporation to The Flather Mfg. Co. E. J. Flather is retiring from the active management but will continue with the company as consulting engineer. H. E. Flather is president and Edwin Morey, treasurer.

Aborn Steel Co., Inc., 26 Clarke St., New York City, have been appointed sales agents for the Century Steel Co. of America, Inc., Poughkeepsie, N. Y., manufacturers of crucible steels. The Century Steel Co. of America have given up their New York office and warehouse and the Aborn Steel Co. will carry Century products in stock.

Union Switch & Signal Co., Swissvale, Pa., have recently placed orders for additional equipment consisting of two 3000-pound steam drop-hammers, one 8000-pound steam drop-hammer, and presses which, added to their present equipment, will place them in a position to handle additional orders for forgings for automobiles, war trucks and airplane parts.

Alfred Box & Co., Front and Poplar Sts., Philadelphia, Pa., manufacturers of cranes and hoists, were sold by the estate of Alfred Box, on March 1, 1918, to Herman L. Winterer and Ambrose G. Warren, the sale covering the firm name, machinery, good will, and fixtures in the crane and hoist business conducted by the company. The business will be carried on by the purchasers under the old name of Alfred Box & Co.

Buhr-Buiwitt Co., 1662 Dubois St., Detroit, Mich., have taken over the exclusive sales of the Detroit Pneumatic Chuck Co., Flat Rock, Mich., for the United States and Europe. The Detroit Pneumatic Chuck Co. have been under the management of the Buhr-Buiwitt Co. since April 1. The chuck manufactured by the company is especially suitable for shell work, but is also applicable to all kinds of manufacturing work.

Ott Grinder Co., Indianapolis, Ind., state that Albert J. Ott and his son Conrad have sold their controlling interest in the company, and the purchasers will continue the manufacture of small, plain, and universal cylindrical grinders, under the management of Russell Fortune. Messrs. Ott have agreed not to manufacture small cylindrical grinders for five years, but are privileged to build large-swing machines, which they probably will do in the near future.

Brown Instrument Co., Philadelphia, Pa., have recently let a contract to R. C. Ballinger & Co. for an addition to their factory, which will cost approximately $50,000. The addition will be erected at Wayne and Roberts Aves., adjoining the present building. The company is manufacturing pyrometers used in the heat-treatment of munitions for the United States Government. The officers are Richard P. Brown, president; C. Stanley Hurlbut, vice-president; George W. Cornman, secretary; and John P. Goheen, assistant treasurer.

Foster Machine Co., Elkhart, Ind., manufacturers of turret lathes, have acquired the sole rights for the manufacture and sale of Holden-Morgan thread millers in the United States and all foreign countries. The machines, which will be built under the patent rights of the Holden-Morgan Co., are now designed and built for all classes of munitions, including the largest sizes of shells, and all component parts, such as time fuses, graze fuses, detonators, sockets, and primers, as well as gun parts and many parts of airplanes, including turnbuckles.

H. L. Hopwood, industrial lawyer, New First National Bank Bldg., Columbus, Ohio, is making a specialty of dealing in factory plants, foundries, and mills that are privately offered for sale, and thereby provides an opportunity to industrial enterprises which seek to acquire plants already constructed rather than to build their own plants. Confidential relations with owners of such properties have made it possible to list a number of well-equipped plants capable of being easily converted for the manufacture of various industrial products.

Akerlund & Semmes, Inc., consulting engineers, 17 Battery Place, New York City, have been appointed representatives of the Gibbs Gas Engine Co., Jacksonville, Fla., and of the Western Pipe & Steel Co., San Francisco, Cal., in connection with contracts held by these companies for the Navy Department and the United States Shipping Board Emergency Fleet Corporation, respectively. The Gibbs Gas Engine Co. have a contract for thirty-five submarine chasers, while the Western Pipe & Steel Co. have a contract for twenty-eight 8800-ton steel vessels.

Mount Vernon Die Casting Corporation., Mount Vernon, N. Y., have been incorporated under the cooperative plan by twenty-nine skilled mechanics to take over the business of C. J. Moberg, Inc., maker of die-castings. Mr. Moberg wished to retire from the die-casting field, and as difficulty had been experienced in employing this kind of labor the cooperative plan was tried. George H. Lane, secretary and treasurer of C. J. Moberg, Inc., is secretary, treasurer, and general manager of the Mount Vernon Die Casting Corporation. The president of the new company is Edward L. Smith.

Ohio Electric & Controller Co., 5900 Maurice Ave., Cleveland, Ohio, has been incorporated with a capital stock of $200,000 for the purpose of manufacturing lifting magnets and electrical controlling devices. Lifting magnets will be built at once and controlling devices later. The officers of the new company are F. W. Jessop, president; W. B. Greene, vice-president; and A. D. Walter, secretary and treasurer. Mr. Jessop was formerly works manager of the Electric Controller & Mfg. Co., Cleveland, Ohio. He has had an extensive experience in the manufacture of lifting magnets and electrical apparatus for the control of motors.